SUGARBEET RESEARCH

1968 REPORT

COMPILED BY

SUGARBEET INVESTIGATIONS

CROPS RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

A Report to and for
the Sole Use of Cooperators

NOT FOR PUBLICATION

F O R E W O R D

SUGARBEET RESEARCH is an annual compilation of the research accomplishments by staff members of Sugarbeet Investigations and Cooperators. The report is assembled by the Leader of Sugarbeet Investigations, is reproduced at the expense of the Beet Sugar Development Foundation, and is for the sole use of the cooperators. Much of the data will be used in the preparation of manuscripts for technical publications. For this reason, this report does not constitute a publication and its contents should not be used for cited reference. Reproduction of any portion of the material contained herein will not be permitted without the specific consent of the contributor or contributors.

The report presents results of investigations strengthened by contributions received under Cooperative Agreements between Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the Beet Sugar Development Foundation; the Farmers and Manufacturers Beet Sugar Association; Union Sugar Division, Consolidated Foods Corporation; the California Beet Growers Association, Ltd.; and the Red River Valley Sugarbeet Growers Association, Inc.

Trade names occur in this report solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture or the Beet Sugar Development Foundation.

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CONTENTS

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NEW DEVELOPMENTS IN BREEDING RESEARCH

Items Proposed for Seed Increase
May 27, 1968

Breeder seed and inbred lines that have been developed in the breeding research conducted by the staff of Sugarbeet Investigations are proposed for seed production through the Beet Sugar Development Foundation. Seed not needed for planting overwintering plots will be furnished on request to company members of the Foundation for utilization in their breeding programs. Brief descriptions, current designations, and estimates of seed available August 1 are given for the items.

These new productions of breeding research have been developed by the staff of Sugarbeet Investigations in work conducted under Cooperative Agreements with:

California Agricultural Experiment Station
Colorado Agricultural Experiment Station
Michigan Agricultural Experiment Station
Minnesota Agricultural Experiment Station
Utah Agricultural Experiment Station
Beet Sugar Development Foundation
Farmers & Manufacturers Beet Sugar Association
Union Sugar Division, Consolidated Foods Corp.
California Beet Growers Association

Items Proposed for Seed Increase and Utilization

I. U.S. Agricultural Research Station, Salinas, California.

A. Developments in breeding research by J. S. McFarlane, I. O. Skoyen, B. L. Hammond, and R. T. Lewellen:

Item 1. C713 Multigerm . . . . . 1 pound

A yellows-resistant selection from US 75. Six successive selections were made on the basis of root size and freedom from yellowing. A seventh selection was made on the basis of root size and sucrose percentage. C713 is similar to C613 (Item 1, 1967) except for the emphasis on sucrose percentage in the seventh successive selection. Hybrids utilizing C713 as the pollen parent are included in 1968 variety tests.

Suggested utilization: Use as a breeding line. C713 may be increased for use as pollen parent, but suggest waiting until results of hybrid tests are available.

Item 2. C713T Multigerm . . . . . 100 grams

Increase of a tetraploid derived from the yellows resistant C413 (Item 2a, 1965). C413 is the pollen parent in US H9A and US H9B. Tests with triploid hybrids utilizing C713T as the pollen parent are underway.

Suggested utilization: Use as breeding line and as pollen parent in test hybrids.

Item 3. C8535 Monogerm . . . . . 100 grams

Increase of curly top resistant selection from C3534 (Item 1, 1964). C8535 was selected in the greenhouse for resistance to curly top strain 11. A significant improvement was made and only mild symptoms occur when plants are inoculated in the seedling stage with the most virulent curly top strains that have been isolated.

Suggested utilization: Source of curly top resistance and possible use as an inbred parent in F_1 hybrid seed-bearing parents.

Item 4. C8551 Monogerm . . . . . 100 grams

Increase of Type O selection C3550 (Item 1, 1963). C3550 combined good bolting resistance with moderate curly top resistance and has shown good combining ability.

Suggested utilization: (a) Increase for possible use as inbred line, and (b) produce F_1 hybrid using 563HO or 564HO as the seed-bearing parent.

B. Developments in breeding and genetic research conducted by V. F. and Helen Savitsky:

Item 5. S-120 Monogerm . . . . . 150 grams

Tetraploid, monogerm, self-sterile population "Klein E"; good in vigor. Susceptible to curly top.

Item 6. S-507 Multigerm . . . . . 150 grams

Tetraploid, multigerm, self-sterile population of Polish origin. High in sucrose percentage. Susceptible to curly top.

Item 7. S-523 Multigerm . . . . . 150 grams

Tetraploid, multigerm, self-sterile population that is highly resistant to curly top and segregates for 4n Mendelian male sterility. (S-523 is a pollinator for Mendelian male-sterile plants.)

Item 8. S-537 Monogerm . . . . . 100 grams

Tetraploid, monogerm inbred that is leaf spot resistant.

Item 9. S-640 Multigerm . . . . . 150 grams

Tetraploid, multigerm, self-sterile F_3 from hybridization of strain highly resistant to curly top and tetraploid US 401 which is leaf spot resistant. S-640 is good in vigor.

Item 10. S-938 Multigerm . . . . . 150 grams

Tetraploid, multigerm, self-sterile hybrid of US 401 (4n) and Janasz (4n)

II. Crops Research Laboratory, Colorado State University, Fort Collins, Colorado.

Developments in the breeding research of J. O. Gaskill:

Item 11. FC 701/2 Multigerm (Germ. 69 s/g) . . . . . 4.5 pounds

Rhizoctonia resistant; a reselection for Rhizoctonia resistance from FC 701; essentially RR; presumably self sterile; narrow base; rather low in root yield; total number of cycles of selection for Rhizoctonia resistance, 5; source, GW 674-56C.

Suggested utilization: Increase to obtain a quantity of seed for Rhizoctonia resistance comparisons in many areas; and for use in breeding work as a source of genes for Rhizoctonia resistance.

Item 12. FC 702/2 Multigerm (Germ. 83 s/g) . . . . . 3.5 pounds

Rhizoctonia resistant; a reselection for Rhizoctonia resistance from FC 702; about 50% rr; presumably self sterile; narrow base; low in root yield; total number of cycles of selection for Rhizoctonia resistance, 5; source, GW 359-52R.

Item 12 (cont.)

Suggested utilization: Increase to obtain a quantity of seed for Rhizoctonia resistance comparisons in many areas; and for use in breeding work as a source of genes for Rhizoctonia resistance.

Item 13. FC 504 Monogerm (Germ. 72 s/g) . . . . . 3.0 pounds

Leaf spot resistant, type O.rr, inbred line. This line was made available to the Foundation previously. (See Item 12, page 10, Sugarbeet Research, 1964 Report.) However, because of doubt regarding the type O character, the CMS equivalent was not made available at that time. Subsequent tests have indicated that the line is completely type O, or nearly so, and that it is high in combining ability for root yield.

Suggested utilization: Increase.

Item 14. FC 504-CMS Monogerm (Germ. 84 s/g) . . . . . 6.0 pounds

CMS equivalent (B_4) of FC 504; rr.

Suggested utilization: Increase, using FC 504 as the pollinator.

Item 15. FC 602 Monogerm (Germ. 62 s/g) . . . . . 0.5 pound

LSR-CTR, type O ($\pm$), rr, S_2, inbred line, derived from SP 611101-0; may be segregating slightly for aa. Preliminary evidence of high combining ability for root yield has been obtained in a reciprocal top-cross test at Fort Collins. (See entry 504 in Table 2 of the article, "Development and evaluation of sugarbeet breeding material and varieties carrying resistance to leaf spot and curly top, 1966," by Gaskill, Schneider, Murphy, and Coe, in Sugarbeet Research, 1966 Report.)

Suggested utilization: Increase.

Item 16. FC 602-CMS Monogerm (Germ. 60 s/g) . . . . . 1.0 pound

CMS equivalent (B_3) of FC 602; rr.

Suggested utilization: Increase, using FC 602 as the pollinator.

(Seed is already on hand for Items 11 through 16 and could be shipped at any time.)

III. Plant Industry Station, Beltsville, Maryland.

Developments in breeding research of G. E. Coe:

Item 17. SP 67599-0 Monogerm . . . . . 1.0 pound

Type O with good resistance to leaf spot and moderate resistance to black root. It was derived from a cross of FC 502mm type O X multigerm line resistant to leaf spot and black root. Maintainer line for Item 18.

Item 18. SP 67599-02 MS Monogerm . . . . . 1.0 pound

Male-sterile companion line of SP 67599-0. Preliminary combining ability test in 1967 at Beltsville and at East Lansing indicate hybrids are at least equal in productivity to the Michigan commercial hybrid and average leaf spot resistance is equal to SP 6322-0.

Suggested utilization: Production of more experimental hybrids, particularly 3-way hybrids of the combination (SP 6423-01mm MS X SP 67599-0) X multigerm pollinator. Seed increases of Items 17 and 18 will be made at Beltsville.

IV. Crops Research Laboratory, Utah State University, Logan, Utah.

Developments in breeding research of J. C. Theurer and Associates:

Item 19. L-36 Monogerm . . . . . 1.0 pound

Type O ($\pm$), rr, S_3 inbred pollinator derived from CT 5A material. L-36 has shown extremely high resistance to curly top, both in field and greenhouse tests, and good combining ability with other inbred lines. Current Seed No. 756.

Suggested utilization: Increase and use as a pollinator for the production of curly top resistant hybrids.

Item 20. L-3T Multigerm . . . . . 500 grams

C_2 Tetraploid of US 201 X LSR-CTR selection.

Item 21. L-4T Multigerm . . . . . 250 grams

C_2 Tetraploid of [US 35/2 X Ovana) X CT 9] X CT 5.

Item 22. L-6T Multigerm . . . . . 90 grams
C_2 Tetraploid of CT 5B

Item 23. L-8T Multigerm . . . . . 500 "
C_2 Tetraploid of CT 8

Item 24. L-9TCMS Monogerm . . . . . 90 "
C_1 Tetraploid of CT 9 mm CMS

Item 25. L-9T Monogerm . . . . . 80 "
C_1 Tetraploid of CT 9 mm

Item 26. L-10T Multigerm . . . . . 50 "
C_2 Tetraploid of CT 9A

Item 27. L-11T Multigerm . . . . . 500 "
C_2 Tetraploid of CT 9 X CT 5 selection.

Item 28. L-12T Multigerm . . . . . 150 "
C_2 Tetraploid of Line 289, a high sugar selection with rather poor combining ability.

Item 29. L-23T Monogerm . . . . . 200 "
C_2 Tetraploid of SLC 122-19.

Item 30. L-28T CMS Monogerm . . . . . 50 "
C_2 Tetraploid of SLC 128 CMS

Item 31. L-33T CMS Monogerm . . . . . 250 "
C_2 Tetraploid of SLC 133 CMS

Item 32. L-33T Monogerm . . . . . 500 "
C_2 Tetraploid of SL 133

Item 33. L-53T Multigerm . . . . . 100 "
C_2 Tetraploid of line released in 1966 as L-53.

(Note: Items 20 through 33 were tetraploidized in Spain under PL 480 and are proposed for release to the Foundation.)

UTILIZATION OF USDA SEED RELEASES, 1968

Item numbers and seed numbers are identical with those listed in the release memorandum dated May 27, 1968.

I. U. S. Agricultural Research Station, Salinas, California

A. Developments in breeding research by J. S. McFarlane, I. O. Skoyen, B. L. Hammond, and R. T. Lewellen.

Item 1. C713 Multigerm . . . . . 1.0 pound

From the available amount, Amalgamated, American Crystal, and Utah-Idaho each want 50 grams now; Great Western and Spreckels each want 25 grams now, and Holly wants 20 grams now. The balance of the seed will be used for an increase by the West Coast Beet Seed Company, the increase to be shared by American Crystal, Holly, Spreckels and Union.

Item 2. C713T Multigerm . . . . . 100 grams

The available seed will be shared now by Amalgamated, American Crystal, Great Western, Holly, Spreckels, Union, and Utah-Idaho.

Item 3. C8535 Monogerm . . . . . 100 grams

Same distribution as noted for Item 2.

Item 4. C8551 Monogerm . . . . . 100 grams

The amount of seed available will be placed into two separate plantings by the West Coast Beet Seed Company. One planting will be of sufficient size to provide stecklings for Amalgamated, American Crystal, Holly, Spreckels, Union, and Utah-Idaho. The balance of the seed will be planted for an increase to be shared by American Crystal, Great Western, Holly, Spreckels, and Union.

B. Development in breeding and genetic research conducted by V. F. and Helen Savitsky.

Item 5. S-120 Monogerm . . . . . 150 grams

The amount of seed available will be distributed now among the following companies: American Crystal, Great Western, Holly, Spreckels, and Union.

Item 6. S-507 Multigerm . . . . . 150 grams

Same distribution as noted for Item 5.

Item 7. S-523 Multigerm . . . . . 100 grams

The amount of seed available will be distributed now among the following companies: Amalgamated, American Crystal, Great Western, Holly, Spreckels, Union, and Utah-Idaho.

Item 8. S-537 Monogerm . . . . . 100 grams

Same distribution as noted for Item 5.

Item 9. S-640 Multigerm . . . . . 150 grams

Same distribution as noted for Item 7.

Item 10. S-938 Multigerm . . . . . 150 grams

Same distribution as noted for Item 5.

II. Crops Research Laboratory, CSU, Fort Collins, Colorado

Developments in breeding research by J. O. Gaskill.

Item 11. FC 701/2 Multigerm (Germ. 69 s/g) 4.5 pounds

From the available amount, American Crystal, Holly, and Utah-Idaho each want 50 grams now; Amalgamated wants 200 grams now, and Spreckels wants 250 grams now. The balance of the seed will be used for an increase by the West Coast Beet Seed Company, the increase to be shared by American Crystal and Great Western.

Item 12. FC 702/2 Multigerm (Germ. 83 s/g) 3.5 pounds

Same distribution as noted for Item 11.

Item 13. FC 504 Monogerm (Germ. 72 s/g) 3.0 pounds

From the available amount, American Crystal, Holly, Spreckels, and Union each want 50 grams now, and Amalgamated wants 200 grams now. The balance of the seed will be used for an increase by the West Coast Beet Seed Company, the increase to be shared by American Crystal, Great Western, Holly, and Spreckels.

Item 14. FC 504-CMS Monogerm (Germ. 84 s/g) 6.0 pounds

From the available amount, American Crystal, Spreckels, and Union each want 50 grams now; Amalgamated wants 200 grams now, and Holly wants 100 grams now. The balance

of the seed will be used for an increase by the West Coast Beet Seed Company, the increase to be shared by American Crystal, Great Western, Holly, and Spreckels.

Item 15. FC 602 Monogerm (Germ. 62 s/g) 0.5 pound

From the available amount, a small planting will be made in the variety plots of the West Coast Beet Seed Company from which American Crystal and Spreckels will be able to obtain stecklings. Amalgamated, Union, and Utah-Idaho want 20 grams, 20 grams, and 10 grams, respectively, now. The balance will be placed into an increase plot by West Coast Beet Seed Company, the increase to be shared by Amalgamated, American Crystal, Great Western, Holly, Union, and Utah-Idaho.

Item 16. FC 602-CMS Monogerm (Germ. 60 s/g) 1.0 pound

Same use as noted for Item 15. Amalgamated, Union, and Utah-Idaho want 40 grams, 20 grams, and 10 grams, respectively, now.

III. Plant Industry Station, Beltsville, Maryland

Developments in breeding research by G. E. Coe.

Item 17. SP 67599-0 Monogerm . . . . . 1.0 pound

From the available amount, American Crystal, Holly, and Spreckels each want 50 grams now, and Great Western wants 10 grams now. The balance of the seed will be used for an increase by the USDA at Beltsville, the increase to be shared by American Crystal and Great Western.

Item 18. SP 67599-02 MS Monogerm . . . . . 1.0 pound

Same distribution as noted for Item 17.

IV. Crops Research Laboratory, Utah State University, Logan, Utah

Developments in breeding research of J. C. Theurer and Associates.

Item 19. L-36 Monogerm . . . . . 1.0 pound

Same distribution as noted for Item 7.

Item 20. L-3T Multigerm . . . . . 500 grams

Same distribution as noted for Item 7.

Item 21. L-4T Multigerm . . . . . 250 grams

Same distribution as noted for Item 7.

Item 22. L-6T Multigerm . . . . . 90 grams

Same distribution as noted for Item 7.

Item 23. L-8T Multigerm . . . . . 500 grams

Same distribution as noted for Item 7.

Item 24. L-9TCMS Monogerm . . . . . 90 grams

Same distribution as noted for Item 7.

Item 25. L-9T Monogerm . . . . . 80 grams

Same distribution as noted for Item 7.

Item 26. L-10T Multigerm . . . . . 50 grams

Same distribution as noted for Item 7.

Item 27. L-11T Multigerm . . . . . 500 grams

Same distribution as noted for Item 7.

Item 28. L-12T Multigerm . . . . . 150 grams

Same distribution as noted for Item 7.

Item 29. L-23T Monogerm . . . . . 200 grams

Same distribution as noted for Item 7.

Item 30. L-28T CMS Monogerm . . . . . 50 grams

Same distribution as noted for Item 7.

Item 31. L-33T CMS Monogerm . . . . . 250 grams

Same distribution as noted for Item 7.

Item 32. L-33T Monogerm . . . . . 500 grams

Same distribution as noted for Item 7.

Item 33. L-53T Multigerm . . . . . 100 grams

Same distribution as noted for Item 7.

ABSTRACTS OF PAPERS APPROVED FOR PUBLICATION IN 1968

BILGEN, TALAT, J. O. GASKILL, R. J. HECKER, and D. R. WOOD. Transferring Cercospora leaf spot resistance from Beta maritima to sugarbeet by backcrossing. J. Am. Soc. Sugar Beet Technol. (In press).

This study was made as an evaluation of: (a) Beta maritima as a source of Cercospora leaf spot resistance; and (b) the backcross method of plant breeding as a tool for transferring leaf spot resistance from B. maritima to sugarbeet.

A comparison of the leaf spot readings on bolting vs. non-bolting plants showed that the bolting phenomenon was positively associated with leaf spot susceptibility in this experiment; thus it was concluded that leaf spot readings should not be taken on bolting plants in a leaf spot breeding program.

Genetic variation and heritability ratios for leaf spot were relatively low in open-pollinated backcross populations, due to an over estimation of the environmental variance. However, it was apparent from the study of leaf spot frequency distributions that there were highly resistant individuals with acceptable weight and sucrose percentage in the backcross progenies, especially in the B_2OP_1. Selection of such individuals in a large population should make possible substantial progress toward the development of a leaf spot resistant sugarbeet variety.

COE, G. E. Relative damage of Cercospora leaf spot on sugarbeet varieties. J. Am. Soc. Sugar Beet Technol. 15(2): 94-98. 1968.

Cercospora leaf spot caused a decrease in root yield and sugar percentage in the three varieties tested. Gross sugar production in diseased sugarbeets was related to the resistance of the varieties tested. The most resistant variety declined less than the two other varieties in percent sucrose when a severe leaf spot infestation was present.

DUFFUS, JAMES E. Beet yellowing viruses in the U.S.A. Invitational paper at the First International Congress of Plant Pathology, London, England, July 14-28, 1968.

Five yellowing viruses have been described from the complex of beet yellowing diseases called yellows in the U.S.A.: (a) semi-persistent aphid-transmitted viruses with rather restricted natural weed host ranges and localized distribution (beet yellows virus, beet yellow stunt virus); (b) persistent aphid-transmitted viruses with extremely wide natural weed host ranges and widespread distribution (beet western yellows virus, malva yellows virus); and (c) a whitefly-transmitted virus (beet pseudo-yellows virus).

Currently, two of these viruses, beet yellows virus and beet western yellows virus, are causing major economic damage to sugarbeet. The other viruses seem to be of relatively greater importance on other crops--lettuce, spinach and the crucifers.

Beet yellows virus is a serious threat only in areas in which beets are overwintered either as a crop or as weeds. Other wild hosts apparently play an unimportant role in the distribution of this virus throughout the U.S.A. and the world.

Beet western yellows virus has a much wider distribution throughout the U.S.A. than the beet yellows virus. It is widely distributed throughout the Western States and is easily found in Eastern beet growing areas. Yellowing viruses of a similar nature are found throughout the world.

DUFFUS, JAMES E. and A. H. GOLD. Membrane feeding and infectivity neutralization used in a serological comparison of potato leaf roll and beet western yellows viruses. Virology 37: 150-153. 1969.

Green peach aphids Myzus persicae (Sulzer) successfully acquired potato leaf roll virus (PLRV) when fed through artificial membranes on density-gradient fractions prepared from infected potato (Solanum tuberosum L.), Physalis floridana Rydb. and Datura stromonium L.

Infectivity neutralization by antiviral antibodies was used in a serological comparison of PLRV and beet western yellows virus (BWYV). Virus extracts were mixed directly with antiserum to BWYV, incubated, and subjected to density-gradient centrifugation. The virus zones were removed from the tubes and fed to aphids through membranes. BWYV antiserum completely neutralized all infectivity of BWYV isolates, but did not affect infectivity of PLRV isolates.

Strains of BWYV in P. floridana did not cross-protect against PLRV.

GASKILL, JOHN O. Breeding for Rhizoctonia resistance in sugarbeet. J. Am. Soc. Sugar Beet Technol. 15(2): 107-119. 1968.

Studies on breeding sugarbeet for resistance to Rhizoctonia root and crown rot at Fort Collins, Colorado, from 1957 through 1966, included research on disease exposure techniques as well as the actual selection of plants and evaluation of progenies for resistance. High lights are as follows:

1. The application of dry, ground, barley-grain inoculum in the center of the foliar rosette (the so-called "rosette method"), 3 to 5 weeks after thinning, is considered the most dependable of the various inoculation techniques studied. This method is quite simple and relatively inexpensive.

2. Substantial improvement in Rhizoctonia resistance has been achieved by selection in various sugarbeet populations. It is not known whether this improved resistance is effective against a wide range of Rhizoctonia races or biotypes. It apparently is relatively ineffective in early seedling stages.

3. Two Rhizoctonia resistant lines (FC 701 and FC 702), products of four cycles of mass selection for resistance, have been made available to the sugarbeet industry. They are not suitable for use as commercial varieties, and are considered valuable primarily as sources of genes for Rhizoctonia resistance.

GASKILL, JOHN O. A method of selecting individual sugarbeet roots for weight and sucrose percentage. J. Am. Soc. Sugar Beet Technol. (In press).

A mathematical technique has been devised by which individually analyzed mother beets may be selected with a curvilinear relationship between weight and sucrose percentage.

HADDOCK, JAY L., GEORGE K. RYSER, and J. C. THEURER. Mineral composition of sugarbeet plants as affected by varieties and genotypes. J. Am. Soc. Sugar Beet Technol. (In press).

Twenty-one sugarbeet varieties were grown on the same soil and analyzed for various plant nutrients. Statistically significant differences were obtained among the 21 genotypes for each nutrient element studied. The range in chemical composition, while statistically significant, was relatively small. This suggests that it is feasible to use a standard chemical analysis for critical levels (and more particularly to use quantity-quality factors) in appraising the nutritional status of newly released commercial varieties, without danger of being misguided in the use of fertilizer or soil amendments.

HINE, R. B., D. L. JOHNSON, J. L. SEARS, E. RUPPEL, and O. C. ZIRKLE. Root rot causes sugar beet loss. Prog. Agr. Arizona 20(2): 4-5. 1968.

A soil-borne fungus, Pythium aphanidermatum, has been shown to be responsible for a serious root rot of mature sugar beets in the Safford, Eden, Bryce, and Thatcher areas of Graham County, Arizona. High disease incidence occurred during July and August, 1967, but decreased during September and October. Total loss in the area was approximately 30 percent, with losses in individual fields ranging from about 10 to 50 percent. The disease, although known to occur in California and Colorado, has not previously been reported from Arizona.

HOEFERT, LYNN L. Ultrastructure of pollen development in Beta. I. Cytoplasmic constituents. Amer. J. Bot. (In press).

Cytoplasmic structure of developing pollen grains of Beta vulgaris L. was studied with the electron microscope. Development progresses in the following order: diads, tetrads, early microspores, vacuolate microspores, binucleate pollen grains, and fully mature pollen with a vegetative cell and two sperm nuclei. All stages except the last were studied. Two unique cytoplasmic features were encountered--the reticulum complex and cytoplasmic microtubules--both of which were present from the last meiotic stage to the binucleate pollen grain stage. The reticulum complex is connected to the nuclear membrane and juxtaposed to the plasma membrane and may function in synthesis or movement of materials through the pollen cytoplasm.

HOEFERT, LYNN L. Proteinaceous and virus-like inclusions in cells infected with beet mosaic virus. Virology, Short Communications. (In press).

Sugarbeet leaf cells collected from healthy and mosaic-inoculated plants were examined with the electron microscope. Cytoplasmic inclusions, in the form of pinwheels and bundles, were observed, and virus-like particles were seen in infected cytoplasm. The presumptive virus particles corresponded in size to particles seen in leaf dip preparations by others. Cytoplasmic pinwheel and bundle inclusions were digestible with proteolytic enzymes but were not affected by ribonuclease treatment. Short, immature bundle inclusions and virus-like particles were found adjacent to mature sieve elements six days after inoculation. Mature inclusions were present eight to twelve days after inoculation and were more widely distributed in the leaf cells than those found six days after inoculation.

LEWELLEN, R. T., J. S. McFARLANE, and I. O. SKOYEN. Virus yellows infected sugarbeet varieties: Effects of harvest dates and nitrogen availability. J. Am. Soc. Sugar Beet Technol. (In press).

Moderately resistant line 13 and moderately susceptible variety US 75 from which line 13 was selected were compared under yellows infected and noninfected conditions, under high and low nitrogen levels, and over 8 dates of harvest. Data were obtained for root yield, sucrose %, and concentrations of amino-N, Na, K, and petiole-NO_3. When noninfected, US 75 and line 13 were not different for root yield or sucrose % but were significantly different for amino-N, Na, and K. The amino-N and Na concentrations were higher in US 75. When infected, line 13 produced 68% more gross sugar than US 75. Concentrations of amino-N, Na, and K were increased by yellows infection in US 75 but were not changed in line 13. When infected, line 13 increased in gross sugar production for a longer time than US 75. The nitrogen treatments caused greater differences in US 75 than in line 13.

McFARLANE, J. S. Elimination of downy mildew as a major sugarbeet disease in the coastal valleys of California. Plant Disease Reporter 52: 297-299. 1968.

Downy mildew was one of the most damaging diseases of the sugarbeet in the coastal valleys of California prior to 1954. Open-pollinated varieties with moderate resistance were developed and these replaced susceptible varieties in the early 1950's. Monogerm hybrid varieties with moderate resistance have now replaced the open-pollinated varieties. The disease has been of minor importance since the moderately resistant varieties have come into general use. Although none of our present varieties is highly resistant, the level of resistance appears to be sufficient to prevent widespread infection and damage. Sugarbeet breeding lines with high resistance are available and this resistance could be incorporated into commercial varieties if the disease should again threaten to cause economic losses.

McFARLANE, J. S. Breeding sugarbeet varieties for California. California Sugar Beet. 28-30. 1968.

This is a semi-popular article describing breeding methods and accomplishments of the USDA breeding program at Salinas and Brawley. The work with virus yellows resistance is emphasized.

McFARLANE, J. S. Breeding for resistance to curly top. Jour. of the Int. Inst. for Sugar Beet Research. (In press).

This is an invitational paper which was presented by proxy at the 32nd I.I.R.B. winter congress in Brussels, February 27-28, 1969. The paper traces the history of curly top resistance breeding in the United States. Accomplishments and future plans are discussed.

McFARLANE, J. S. and C. W. BENNETT. Selecting and testing sugarbeet for curly top resistance in the greenhouse. Phytopathology 58: 1311-1315. 1968.

A greenhouse method of selecting for curly top resistance in the sugar beet has been developed. Viruliferous beet leafhoppers are caged on seedlings for 1 week, and the plants are graded for severity of symptoms 6 weeks after inoculation. Plants with the mildest symptoms are selected and selfed seeds produced. At least eight plants of each selfed progeny are tested. Those progenies showing the best resistance are retested through the use of a larger number of plants.

The mass selection method commonly used in the field does not work as well in the greenhouse because of plant variation caused by environmental factors. Progeny tests are necessary and are made most readily with self-fertile populations of sugar beet. A marked increased in resistance was obtained from self-fertile populations showing wide ranges of segregation.

The curly top resistance of sugar beet varieties and selections can be determined in the greenhouse. Although environmental variation influences the severity of symptoms of individual plants, a reliable rating is obtained if 40 or more plants are tested. The greenhouse method is especially useful in determining the resistance of new breeding lines to the more virulent strains of the curly top virus.

McFARLANE, J. S. and I. O. SKOYEN. New sugar beet varieties reduce losses from virus yellows. California Agriculture 22(9): 14-15. 1968.

Two hybrid sugar beet varieties with moderate resistance to virus yellows have been released to California growers. The varieties designated US H9A and US H9B are both monogerm and were developed at the U.S. Agricultural Research Station, Salinas. The new varieties perform best in those areas of the State in which damage from yellows is severe, but they also perform well under yellows-free conditions. In 17 tests under conditions of moderate to severe yellows, US H9A produced 22 per cent

more sugar than did the widely grown US H7 variety. In 11 tests, US H9B produced a 27 per cent higher yield of sugar than did US H7. Both varieties averaged about 0.3 of a percentage point higher in sucrose than did US H7. Seed has been produced by the sugar companies and is now available for wide scale planting.

McFARLANE, J. S., I. O. SKOYEN, and R. T. LEWELLEN. Development of sugarbeet breeding lines and varieties resistant to yellows. J. Am. Soc. Sugar Beet Technol. (In press).

Selections for resistance to beet yellows virus (BYV) and beet western yellows virus (BWYV) were made on the basis of freedom from disease symptoms and on root size. Improvements in resistance were obtained in both self-sterile and self-fertile sugarbeet lines. Root-yield losses from yellows averaged 20.4% for a seventh successive selection from US 75 compared with 41.4% for the parent. Under severe yellows, the selection produced an average 53% higher root yield and was 0.8 percentage points higher in sucrose than US 75. Under light yellows infection the performance of the selection was similar to that of the parent. Hybrids between monogerm male steriles and yellows-resistant selections performed well under both severe and light yellows infection. Two hybrids that utilized a US 75 selection as the pollen parent have been released as commercial varieties with the designations US H9A and US H9B.

MUMFORD, D. L. Evaluating soil samples for fungus pathogens of sugarbeet seedlings. J. Am. Soc. Sugar Beet Technol. (In press).

A simple procedure for identification of soil-borne fungi infecting sugarbeet seedlings is described. This procedure is used in conjunction with a plant infection test to evaluate soil samples for presence of fungus pathogens. The data indicate wide differences in abundance of pathogens in different fields. In areas where seedling diseases are serious, an evaluation of soil samples for disease potential would be helpful in choosing favorable fields for planting.

RUPPEL, E. G. Possible particles of beet western yellows virus in the intestines of viruliferous aphids. Phytopathology 58: 256-257. 1968.

Green peach aphids, Myzus persicae, (initially aviruliferous) were kept for 2 weeks on a sugarbeet infected with beet western yellows virus (BWYV). The alimentary canals of aphids shown to be viruliferous in a transmission test and of aviruliferous aphids were removed, fixed in 6% glutaraldehyde, postfixed in 1% osmium tetroxide, dehydrated in an ethanol-propylene oxide series, and embedded in epoxy resin. The fixatives were prepared in an insect Ringer solution (pH 7.0). Ultrathin sections through the anterior intestine were stained in uranyl acetate and lead citrate and examined in the electron microscope. Numerous spherical particles were observed in the intestinal lumen and cellular cytoplasm of viruliferous aphids but not in aviruliferous aphids. The size and shape of the particles coincided with that of purified BWYV (J. E. Duffus, personal communication).

SAVITSKY, HELEN. Effect of low colchicine concentrations on inducing autotetraploidy in sugarbeets. J. Am. Soc. Sugar Beet Technol. (In press).

The pregerminated seed of 10 sugarbeet strains were treated by 0.05%, 0.1%, and 0.4% colchicine concentrations. A colchicine concentration 0.05% is too low to induce tetraploidy in the majority of strains. A higher concentration 0.1% affected seedlings in the majority of strains, but did not produce a large number of tetraploids. The concentration 0.4% produced the largest number of tetraploids in all strains. Individual sugarbeet strains demonstrated different responsiveness to colchicine concentrations. Three of 10 strains did not produce tetraploids at concentrations 0.05% and 0.1%, whereas 1 strain responded well to concentration 0.05%, and the concentration 0.1% was as effective for it as the concentration 0.4%. For the lines which present difficulties in being converted into tetraploids the suitable colchicine concentrations should be found experimentally.

SAVITSKY, HELEN. Meiosis in hybrids between Beta vulgaris L. and Beta corolliflora Zoss. and transmission of resistance to curly top. Proc. XII International Congress of Genetics. (In press).

An F_1 tetraploid hybrid between 4n sugarbeet and 4n B. corolliflora, which is highly resistant or immune to curly top, was obtained by V. F. Savitsky. The b_1 and b_2 hybrid generations were produced by backcrosses to diploid sugarbeets. Hybrids were inoculated with curly top virus by C. W. Bennett and selected for resistance. Vulgaris-corolliflora hybrids are amphidiploids i.e. pairing of chromosomes, as a rule, is autocyndetic - between identical genomes. Selected b_1 plants highly resistant to curly top were triploid or triploid-aneuploid. In meiosis of 3n hybrids, 9 B. vulgaris bivalents and 9 B. corolliflora univalents were formed. Occasionally 1-2 trivalents were observed. Highly resistant and curly top immune b_2 hybrids were selected. They carried 2 to 5 B. corolliflora chromosomes in addition to the diploid set of B. vulgaris chromosomes. Transmission of resistance is due to transmission of B. corolliflora univalents, some of which divided in the first meiotic division.

SCHNEIDER, C. L., ALI M. JAFRI, and ALBERT M. MURPHY. Greenhouse testing of sugar beet for resistance to curly top. J. Am. Soc. Sugar Beet Technol. 14(8): 727-734. 1968.

Studies to increase the efficiency of greenhouse tests showed that adherence to the following procedures ensures likelihood of disease incidence adequate for proper evaluation of curly top resistance: 1) Use of plants with severe curly top symptoms as virus source for leafhopper vectors; 2) Exposure of test seedlings to leafhopper vectors (one per cotyledon) for a minimum period of 3 days beginning not later than 17 days after planting; 3) Maintenance of temperature of at least 25° C and relatively high light intensity, as provided in a typical growth chamber. Reliability of greenhouse tests was indicated by concordance between repeated tests and by similarity of results of greenhouse and field tests.

SKOYEN, I. O. Sugarbeet responses to selective gametocide, sodium 2,3-dichloroisobutyrate and related chemicals. J. Am. Soc. Sugar Beet Technol. (In press).

Effects on sugarbeet of three selective gametocide chemicals, 2,3-dichloroisobutyrate, FW-450, and the related chlorinated organic salts, FW-676 and G-315 (Rohm & Haas, Philadelphia, Pa.), were evaluated in three experiments. A series of 2-3 spray applications using concentrations of 0.15, 0.22 and 0.3 percent at 5 to 15-day intervals were started when test plants were in early bud. Pollen sterility developed in 10-14 days and was maintained for periods of 5-7 weeks. Treated self-fertile plants had as high as 89 percent cross pollinated seed. All chemicals were phytotoxic. Damage included contact burn, tissue chlorosis and necrosis, distorted growth, reduced seed yields and low germination. Phytotoxicity increased with higher concentrations and longer treatment intervals. Sugarbeet lines responded differently to the gametocides. Deformed seedlings (7.2 percent) were found in the progeny of plants treated in a greenhouse experiment. Cytological examination of deformed seedlings showed a portion to be polyploid. In the 1963 breeding program at Salinas, California, 32 of 34 crosses using gametocide treated self-fertile lines as females produced 58-100 percent cross-pollinated seed.

STOUT, MYRON. Rapid methods for evaluating individual sugar beets for quality factors and root-respiration rate. (Approved for publication but journal not determined).

Sampling and analysis of individual sugar beets for processing quality can be accomplished quickly and with little damage to subsequent growth of the root. A single, 22 mm cylinder of tissue cut horizontally below the crown is adequate for both respiration rate measurement and chemical analysis. A summation of the individually determined impurities (amino N, Na and K) in relation to sugar, has been shown to be highly correlated (negatively) with extractable sugar. These four chemical determinations can be made on a single blended diffusate at a rate of 2 samples per minute and at a labor cost of less than $.30 per sample exclusive of supervision. Such quality evaluations are flexible in adjustment to improvements in processing technology. Respiration-rate evaluation, while more time consuming, is also a heritable and important character where beets are stored for long periods before processing.

STOUT, MYRON. Photosynthesis and respiration studies with sugar beets. II. The effect of previous light exposure on rates as measured by CO_2 exchange. (Approved for publication but journal not determined).

Net accumulation and respiration rates of intact sugar beet plants (Beta vulgaris L.) were measured following preconditioning in darkness and at two light intensities. All plants were grown and preconditioned in a growth chamber. Plants preconditioned in darkness had a very slow initial rate of CO_2 uptake when illuminated at 3877 ft-c. The rate increased rapidly and reached a semi-plateau after about 60 minutes,

although the rate continued to increase slowly. Plants preconditioned at higher light intensities had higher initial net accumulation rates, increased more slowly, but were lower than those from darkness after 60 minutes, although the rate of increase was greater. Respiration rates were higher following illumination than after prolonged darkness. Differences in light quality (ft-c versus ergs/cm^2 sec) between the growth chamber and photosynthesis chamber are reported.

THEURER, J. C. Inheritance of a lutescens mutant in sugarbeets Beta vulgaris L. Crop Science 8: 422-423. 1968.

A seedling graft technique was used to study the inheritance and linkage of a lethal chlorophyll mutant in sugarbeets, Beta vulgaris L. This lutescens (lu_2) was inherited as a single recessive character and is independent of monogermness, Mendelian-male-sterility or genes in the well-known Y-R-B linkage group.

THEURER, J. C. Linkage tests of Mendelian male sterility and other genetic characters in sugarbeets, Beta vulgaris L. Crop Science 8: 698-701. 1968.

Linkage tests involving nine genetic factors in Beta vulgaris L. were conducted in the greenhouse. The genetic male sterile (a_1) gene was inherited independently from eight other factors. Linkage between red hypocotyl color (R) and trout leaf (Tr) and lack of association of monogerm (m) and russett root (ru) with the Y-R-B linkage group, as noted by other research workers, was confirmed. The dwarf factor (d) and lutescens (lu_2) appeared to be independent of the Y-R-B group. The ru and lu_2 characters are not associated with m. A summary table of linkage groups in sugarbeets and linkage maps for two of these groups are presented.

THEURER, J. C., R. J. HECKER, and E. H. OTTLEY. Attempted graft transmission of cytoplasmic male sterility in sugar beets (Beta vulgaris L.) J. Am. Soc. Sugar Beet Technol. 14(8): 695-703. 1968.

Transmission of a cytoplasmic male sterility or fertility factor(s) through a graft union was attempted in sugarbeets. All graft combinations maintained phenotypic autonomy. It is doubtful that this technique will become an effective means of producing cytoplasmic male-sterile populations.

SUGARBEET RESEARCH

1968 Report

Section B

U.S. Agricultural Research Station, Salinas, California

Sugarbeet Investigations

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CONTENTS

CONTENTS

DEVELOPMENT OF BREEDING LINES AND VARIETIES FOR CALIFORNIA

J. S. McFarlane, I. O. Skoyen, R. T. Lewellen, and K. D. Beatty

Organization of Breeding Program

The development of monogerm breeding lines and varieties that combine resistance to bolting, curly top, and virus yellows requires the cooperative efforts of several investigators. Dr. McFarlane coordinates the breeding program and gives particular attention to curly top resistance. He is also working with triploid hybrids. Dr. Lewellen has assumed major responsibility for the development of new yellows resistant lines and is placing emphasis on resistant monogerm seed-bearing parents. Mr. Skoyen supervises evaluation tests, develops Type O lines, and is responsible for research on problems associated with monogerm seed. Mr. Beatty supervises variety testing at Brawley and selects for plant characters specifically needed in the Imperial Valley. Dr. Hammond (retired) produced tetraploids from our best diploid breeding lines. Dr. Duffus maintains virus strains and advises as to procedures with the viruses and their vectors. Dr. Fife is continuing his work to find biochemical methods of identifying virus resistant segregates.

Summary of Accomplishments - 1968

US H9A AND US H9B--These moderately yellows resistant varieties were described in the 1967 "Sugarbeet Research" report and in "California Agriculture" 22: (9)14-15. Testing was continued in 1968 and the results are summarized on pages B6, B7, and B9. Yellows infection was light in nearly all parts of California in 1968 thereby providing an opportunity to measure performance under relatively disease free conditions. In 13 tests with light yellows infection the gross sugar yield of US H9A averaged 8 percent higher than for US H7. In 18 tests the sugar yield of US H9B averaged 9 percent higher than for US H7. The average sucrose percentage from the 13 tests was the same for US H9A and US H7. The sucrose percentage of US H9B averaged about 0.15 percentage points lower than for US H7 in 18 tests.

The first commercial acreage of the US H9 hybrids was grown in 1968. Performance reports from both the sugar companies and the growers have been favorable. The rapid emergence and superior seedling vigor of US H9 were observed in many fields. The acceptance of the new varieties is reflected in 1969 orders for 2,565,000 pounds of seed.

BOLTING RESISTANCE--For the first time in 20 years of field testing at Salinas a test was lost from frost. A November planted bolting resistance evaluation test was killed just after emergence. Bolting in January planted variety tests was light. No significant differences occurred among bolting resistant varieties and selections.

DOWNY MILDEW RESISTANCE--No mildew was observed in the Salinas variety tests. Arrangements were made with Dr. Raymond Hull, Head of Broom's Barn Experimental Station, Bury St. Edmonds, England, to test US H7 and US H9A. In the British test US H7 showed 52% and US H9A 63% infection. In the same test Sharpe's E showed 33% infection. Dr. Hull concluded that our hybrids were rather susceptible to downy mildew. Downy mildew has been of minor importance in California for several years and we have attributed this primarily to the improved resistance of our present varieties. Either environmental conditions are much more favorable for mildew in England or different strains of the Peronospora fungus are involved.

We anticipate that US H9 will soon be the predominate variety in the coastal valleys and will watch for any change in the incidence of mildew.

CURLY TOP RESISTANCE--Selections made for curly top resistance in the greenhouse at Salinas were evaluated in the field near Thatcher, Utah, by Dr. D. L. Mumford. Good agreement was observed between the field and greenhouse ratings. Selection work was continued in the greenhouse to find high resistance to the more virulent curly top strains. Progress is illustrated in photographs on page B10. Inbred lines have been selected with very good resistance to the most virulent strains collected by Dr. C. W. Bennett. Preliminary testing at Salinas this past season showed these highly resistant lines to be poor in pollen and seed production. They are included in the 1968-69 nurseries in Oregon. Male sterile monogerm lines with high resistance are being developed.

POLYPLOIDY--Triploid hybrids that used tetraploids produced by Dr. B. L. Hammond as pollinators were evaluated in several variety tests and the results are summarized on page B8. The root yield and sucrose percentage of a monogerm triploid hybrid, 67H4, that used the cross (663 tetra x 486 tetra) as the pollen parent were similar to those of US H7. Multigerm triploids between yellows resistant seed-bearing parents and yellows resistant tetraploids produced sugar yields that were superior to US H7 in most tests. The performance of these yellows resistant triploids was particularly outstanding in tests that were inoculated with yellows. The sucrose percentage of these triploids tended to be inferior to US H7.

Additional triploid hybrids involving yellows resistant parents were produced in 1968 and will be evaluated in 1969. Comparisons between stands and performances of diploid and triploid hybrids when precision planted are also planned.

NEW YELLOWS RESISTANT SELECTIONS--The most promising self-sterile selection in the 1968 tests was Y704, an increase of a cross between YRS 534 and YRS 413. YRS 534 is a Salinas selection from the most yellows resistant line furnished by Dr. Henk Rietberg of the Netherlands. YRS 413 is the seventh successive yellows resistant selection from US 75. Y704 headed a list of 33 hybrids and selections in a yellows inoculated test at Salinas (pages B18 and B19). The selection also ranked among the best performing

entries in a noninoculated Salinas test (page B17) and was outstanding in the Davis test (pages B48 and B49). The bolting resistance of Y704 is good but the curly top resistance is poor. The sucrose percentage of the selection is similar to that of the poorer parent. A test hybrid utilizing Y704 as the pollen parent was produced in 1968 and is being evaluated in 1969 variety trials. A selection is also being made for curly top resistance.

Dr. Lewellen tested a series of yellows resistant lines received in 1967 from Mr. Hendriksen and Dr. Rietberg of the Netherlands. None of these lines proved superior to our own selections but at least one line showed good resistance and could possibly provide resistance genes not present in our material.

Emphasis continues to be placed on the development of yellows resistant monogerm inbreds and their male sterile equivalents. In a Salinas test (page B55) Dr. Lewellen found the three monogerm inbreds 7724, 7705A, and 6707 to offer the greatest promise. Work is underway to further improve these inbreds and to determine their performance in test hybrids.

ASSESSMENT OF BEET QUALITY--Amino N, Na, and K were measured spectrophotometrically in beet samples from a portion of the Salinas and Davis trials. An impurity index was determined through use of Stout's formula $\frac{10 \times \text{amino N} + 25 \times K + 3.5 \times Na}{\text{Sucrose percentage}}$.

No definite conclusions can be drawn from the 1968 results. Varietal differences were indicated for concentrations of amino N, Na, and K. At Salinas, yellows infection generally caused a decrease in purity as shown by the impurity index. Most varieties showed concentration increases for amino N and Na and decreases for K (page B43). At Davis the concentrations of the three impurity components tended to be higher in the inoculated treatments but the increase in amino N and Na was less pronounced than at Salinas.

VARIETY AND COMBINING ABILITY TESTS--Emphasis was placed on the evaluation of yellows resistant selections as parents in hybrid combinations. Yellows and other diseases were of minor importance in most sugarbeet producing areas of California. Root yields were high, especially in the Salinas Valley. Performances of the most promising hybrid combinations are summarized on pages B6 and B7. The hybrid (563HO x 550) x 413 tended to yield higher than either US H9A or US H9B but continued to show a little lower sucrose percentage. The monogerm inbreds 702 and 707 performed well in hybrids. A hybrid utilizing 534 as the pollen parent performed well in six tests. This hybrid is bolting resistant but lacks curly top resistance.

Results of a test with six varieties from Canada, Ireland, England, and California are reported on page B20. US H9B and Sharpe's E produced the highest sugar yield but were significantly lower in sugar yield than the Canadian and Irish varieties.

SUMMARY.--Gross sugar yields of diploid hybrids in 1968
California variety tests, expressed in percent of the yield of US H7

Location	Testing Agency	US H7	US H7A	US H9A	US H9B	13H11	613H4	713H4	13H29	13H35	13H36	13H37	13H39	44H4	34H1
Coastal Area															
Salinas (sprayed)	USDA	100	100	104	105	111	105	108	-	-	-	-	-	-	109
Salinas (yel. inoc.)	"	100	-	113	113	121	121	124	121	113	123	116	127	118	125
Salinas	Union	100	114	115	123	128	122	121	-	-	-	-	-	-	136
Spreckels	Spreckels	100	107	112	103	-	111	114	99	98	-	113	112	110	-
Soledad	"	100	-	-	104	-	-	-	-	-	-	-	-	-	-
Gonzales	"	100	-	-	108	-	-	-	-	-	-	-	-	-	-
Greenfield	"	100	-	-	104	-	-	-	-	-	-	-	-	-	-
King City	"	100	-	-	120	-	-	-	-	-	-	-	-	-	-
San Lucas	"	100	-	-	104	-	-	-	-	-	-	-	-	-	-
Central Valley															
Mendota	"	100	-	119	109	-	-	111	-	-	-	-	-	112	-
Arbuckle	"	100	101	114	-	-	-	-	-	-	-	-	-	-	-
Tulare (Fall)	Holly	100	104	118	125	119	-	119	114	120	124	114	121	-	-
Tulare (Winter)	"	100	-	105	110	117	-	-	-	-	114	-	-	113	118
Famosa	"	100	105	105	101	94	-	-	-	-	101	-	-	-	-
Tracy	"	100	94	-	104	105	-	-	-	-	-	-	-	-	-
Davis	USDA	100	-	103	109	-	-	115	-	-	-	-	-	-	107
Davis (yel. inoc.)	"	100	-	119	129	-	-	125	-	-	-	-	-	-	124
Imperial Valley															
Brawley - Early	"	100	102	110	108	114	115	113	105	105	108	106	109	105	-
Brawley - Late	"	100	104	119	125	123	-	119	-	-	-	-	-	-	-
Calipatria	Holly	100	95	97	96	-	-	97	-	-	97	-	-	-	-
Imp. Valley - Early	"	100	-	106	103	110	109	105	99	96	99	103	104	-	-
Imperial	Union	100	101	117	120	-	-	-	-	105	-	-	-	-	-
El Centro	"	100	100	105	108	-	-	-	-	101	-	-	-	-	-

SUMMARY.--Sucrose percentage of diploid hybrids in 1968 California variety tests, expressed in percent of US H7.

Location	Testing Agency	US H7	US H7A	US H9A	US H9B	13H11	613H4	713H4	13H29	13H35	13H36	13H37	13H39	44H4	34H1
Coastal Area															
Salinas (sprayed)	USDA	100	99	99	96	95	96	99	-	-	-	-	-	-	98
Salinas (yel. inoc.)	"	100	-	98	99	98	98	99	99	98	102	100	103	100	103
Salinas	Union	100	100	98	98	97	99	100	-	-	-	-	-	-	102
Spreckels	Spreckels	100	97	96	95	-	95	97	97	97	-	95	96	96	-
Soledad	"	100	-	-	97	-	-	-	-	-	-	-	-	-	-
Gonzales	"	100	-	-	99	-	-	-	-	-	-	-	-	-	-
Greenfield	"	100	-	-	96	-	-	-	-	-	-	-	-	-	-
King City	"	100	-	-	99	-	-	-	-	-	-	-	-	-	-
San Lucas	"	100	-	-	102	-	-	-	-	-	-	-	-	-	-
Central Valley															
Mendota	"	100	-	105	100	-	-	103	-	-	-	-	-	105	-
Arbuckle	"	100	99	98	-	-	-	-	-	-	-	-	-	-	-
Tulare (Fall)	Holly	100	100	101	100	99	-	95	98	99	98	98	99	-	-
Tulare (Winter)	"	100	-	104	101	100	-	-	-	-	100	-	-	103	104
Famosa	"	100	96	99	99	95	-	-	-	-	99	-	-	-	-
Tracy	"	100	101	-	103	102	-	-	-	-	-	-	-	-	-
Davis	USDA	100	-	99	97	-	-	101	-	-	-	-	-	-	99
Davis (yel. inoc.)	"	100	-	104	102	-	-	107	-	-	-	-	-	-	106
Imperial Valley															
Brawley - Early	"	100	99	96	93	94	96	96	97	94	99	97	89	97	-
Brawley - Late	"	100	99	102	102	103	-	103	-	-	-	-	-	-	-
Calipatria	Holly	100	104	101	98	-	-	101	-	-	100	-	-	-	-
Imp. Valley - Early	"	100	-	98	98	99	98	100	95	95	97	99	96	-	-
Imperial	Union	100	103	104	105	-	-	-	-	100	-	-	-	-	-
El Centro	"	100	100	101	102	-	-	-	-	99	-	-	-	-	-

13H11---(563HO x 550) x 5th YRS US 75
613H4---(562HO x 569) x 7th YRS US 75
713H4---(562HO x 569) x 7th YR, lst suc. sel. US 75
13H29---754HO x 7th YR, lst suc. sel. US 75
13H35---(764H3 x 754) x 7th YR, lst suc. sel. US 75
13H36---(562HO x 707) x 7th YR, lst suc. sel. US 75
13H37---(562HO x 702) x 7th YR, lst suc. sel. US 75
13H39---(715H3 x 707) x 7th YR, lst suc. sel. US 75
44H4----(562HO x 569) x YRS (330 x 234)
34H1----(562HO x 569 + 546) x Rietberg YRS

SUMMARY.--Gross sugar yields of triploid hybrids in 1968 California variety tests, expressed in percent of yield of US H7.

Location	Testing Agency	US H7	30TH32	30TH33	13TH32	13TH34	67H4
Salinas (sprayed)	USDA	100	106	105	111	109	102
Salinas (yel. inoc.)	"	100	107	115	124	124	-
Salinas	Union	100	130	138	125	132	120
Spreckels	Spreckels	100	-	100	-	-	102
Mendota	"	100	-	-	-	-	106
Tulare (Fall)	Holly	100	111	110	-	-	-
Davis	USDA	100	114	120	114	117	-
Davis (yel. inoc.)	"	100	134	141	144	144	-
Brawley - Early	"	100	98	104	110	106	99
Brawley - Late	"	100	-	118	-	-	99
Calipatria	Holly	100	97	-	-	-	-
Imp. Valley - Early	"	100	-	95	-	-	91

SUMMARY.--Sucrose percentage of triploid hybrids in 1968 California variety tests, expressed in percent of US H7.

		US H7	30TH32	30TH33	13TH32	13TH34	67H4
Salinas (sprayed)	USDA	100	94	96	95	93	101
Salinas (yel. inoc.)	"	100	94	98	99	94	-
Salinas	Union	100	100	101	98	98	102
Spreckels	Spreckels	100	-	93	-	-	99
Mendota	"	100	-	-	-	-	102
Tulare (Fall)	Holly	100	95	95	-	-	-
Davis	USDA	100	94	99	97	93	-
Davis (yel. inoc.)	"	100	100	105	101	101	-
Brawley - Early	"	100	89	96	98	92	96
Brawley - Late	"	100	-	98	-	-	100
Calipatria	Holly	100	100	-	-	-	-
Imp. Valley - Early	"	100	-	93	-	-	101

30TH32---(754H4 x 716) x 330T
30TH33---716HO x 330T
13TH32---(754H4 x 716) x 413T
13TH33---716HO x 413T
67H4-----(562HO x 569) x 767

Performance of US H9A and US H9B expressed in percent of the performance of the standard US H7 variety in tests exposed to varying amounts of virus yellows.

Location	No. Tests	Year	Gross Sugar Yield		Percent Sucrose	
			US H9A	US H9B	US H9A	US H9B
Severe yellows						
Salinas Valley	1	1965	116	115	97	103
Salinas Valley	2	1966	126	136	102	103
Sacramento Valley	1	1966	134	136	102	104
Salinas Valley	1	1967	120	122	102	105
Salinas Valley	1	1968	113	113	98	99
Sacramento Valley	1	1968	119	129	104	102
Average			122	127	101	103
Moderate yellows						
Salinas Valley	2	1966	122	118	104	104
Imperial Valley	2	1966	129	141	102	103
Salinas Valley	1	1967	107	--	95	--
Salinas Valley	1	1967	111	110	102	99
Imperial Valley	1	1967	123	124	101	99
Imperial Valley	5	1967	123	--	104	--
Imperial Valley	2	1968	115	117	99	98
Average			121	123	102	101
Light yellows						
Salinas Valley	2	1965	120	--	103	--
Imperial Valley	1	1965	117	--	101	--
Sacramento Valley	1	1966	111	107	101	98
Salinas Valley	3	1967	112	--	100	--
Imperial Valley	2	1967	118	--	102	--
San Joaquin Valley	1	1967	112	--	105	--
Salinas Valley	3	1968	110	110	98	96
Salinas Valley	5	1968	--	108	--	99
Imperial Valley	4	1968	106	107	101	101
Sacramento Valley	1	1968	114	--	98	--
Sacramento Valley	1	1968	103	109	99	97
San Joaquin Valley	1	1968	--	104	--	103
San Joaquin Valley	4	1968	112	111	102	100
Average			112	109	101	99

Curly top resistant selection (left) compared with parent. Selection was made in the greenhouse from self-fertile inbred 594. Plants inoculated in seedling stage with virus strain 11.

Highly curly top resistant 522 monogerm inbred selected in the greenhouse (left) compared with 562 inbred. Plants inoculated in seedling stage with highly virulent Los Banos virus strain.

VARIETY TESTS, BRAWLEY, CALIFORNIA, 1967-68

Location: U.S. Department of Agriculture, Southwestern Irrigation Field Station. 1/

Soil type: Holtville silty clay loam.

Previous crops: Sugarbeets, 1965-66; sweet sorghum and sugarcane, 1966; sesbania, 1967.

Fertilizer used: 44 lbs. per acre phosphorus, actual, and 23 lbs. per acre nitrogen broadcast preplant before listing. 180 lbs. per acre nitrogen sidedressed October 16, 1967.

Planting date: September 25, 1967.

Thinning date: October 11-13, 1967.

Harvest dates: Early harvest, April 30 - May 2, 1968.
Late harvest, June 27-28, 1968.

Irrigations: Early harvest, 8 irrigations plus 2.83 inches rainfall.
Late harvest, 11 irrigations plus 2.83 inches rainfall.

Diseases and insects: Symptoms of a moderate virus yellows infection was apparent throughout the test plot by late February. Curly top infection was of minor importance. The test plot was sprayed three times with methyl parathion during October, 1967, at a rate of one lb. active per acre, for control of cabbage beetle and desert flea beetle. Granular 10 percent Thimet was applied on the test plot January 6, 1968 for control of green peach aphid and leaf miner.

Experimental design: Planted for early harvest, test 1, twenty-two varieties in two-row plots, and test 2, fourteen varieties in single-row plots, each with ten replications and in randomized block design. Planted for late harvest, ten varieties in 10 x 10 latin square design with two-row plots. All plot rows were 40 feet long. Rows spaced 30 inches apart.

Sugar analysis: From two ten-beet samples per plot for tests with two-row plots and from one ten-beet sample per plot for the single-row test by Holly Sugar Corporation, Brawley, California.

Remarks: Test designed and results analyzed by the United States Agricultural Research Station, Salinas, California.

1/ Plot under supervision of K. D. Beatty stationed at Southwestern Irrigation Field Station, Brawley, California.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1968

(10 replications of each variety)
(Two-row plots)

Planted: Sept. 25, 1967
Harvested: May 1, 1968

Variety	Description	Acre Yield		Sucrose	Harvest Count
		Sugar Pounds	Beets Tons	Percent	Number
534H11	(563HO x 550) x 534	7,900	25.53	15.5	136
613H4	(562HO x 569) x 613B	7,800	25.99	15.1	131
F66-13H11	(563HO x 550) x 413	7,760	26.28	14.8	135
713H4	(562HO x 569) x 713	7,660	25.59	15.0	136
544H11	(563HO x 550) x 544	7,610	23.91	16.0	141
U713H4	US H9A	7,490	24.86	15.1	136
713H39	(715H3 x 707) x 713	7,400	26.44	14.0	141
U713H8	US H9B	7,330	25.38	14.6	136
713H36	(562HO x 707) x 713	7,300	23.69	15.5	134
464H11	(563HO x 550) x 464	7,270	23.64	15.5	136
713H37	(562HO x 702) x 713	7,220	23.88	15.2	131
713H38	(760H4 x 702) x 713	7,180	24.29	14.9	135
544H4	(562HO x 569) x 544	7,150	23.73	15.2	130
713H29	754HO x 713	7,150	23.68	15.2	132
713H35	(764H3 x 754) x 713	7,120	24.16	14.8	133
730TH33	716HO x 330T	7,030	23.53	15.0	125
664H8	US H7A	6,900	22.20	15.6	137
664H4	US H7	6,780	21.69	15.7	131
767H4	(562HO x 569) x 767	6,710	22.27	15.1	136
4539H4	US H8	6,700	21.37	15.8	134
730TH32	(754H4 x 716) x 330T	6,670	23.98	13.9	131
664H2	US H6	6,630	22.67	14.7	131
General MEAN of all varieties		7,220	24.03	15.1	Beets per 100' row
S. E. of MEAN		151	0.69	0.38	
Significant Difference (19:1)		420	1.92	1.07	
Coefficient of Variation (%)		6.60	9.06	8.02	
Calculated F value		6.47**	4.38**	1.79*	

* Exceeds the 5% point of significance (F=1.62)

** Exceeds the 1% point of significance (F=1.97)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1968

(10 replications of each variety)
(One-row plots)

Planted: September 25, 1967
Harvested: May 1, 1968

Variety	Description	Acre Yield			Harvest Count
		Sugar Pounds	Beets Tons	Sucrose Percent	Number
613H24	760H4 x 613	8,360	27.91	15.0	135
U713H4	US H9A	8,240	26.65	15.5	141
713TH32	(754H4 x 716) x 413T	7,950	26.47	15.0	130
713H30	(760H4 x 705) x 713	7,770	25.68	15.2	137
713TH34	760H0 x 413T	7,710	27.52	14.1	135
F66-13	Increase 413	7,640	25.65	14.9	136
544	Inc. (330 x 234)	7,600	24.42	15.6	130
613B	YRS 413	7,530	25.48	14.8	133
630TH22	753H4 x 330T	7,280	24.51	14.9	127
664H4	US H7	7,250	23.83	15.3	135
730TH35	(764H4 x 754) x 330T	7,030	24.51	14.4	135
713	YR, Sucrose sel. 413	6,990	22.82	15.3	131
730T	330 tetra	5,880	20.30	14.5	123
F57-68	US 75	5,790	19.09	15.2	133
General MEAN of all varieties		7,360	24.63	15.0	Beets per 100' row
S. E. of MEAN		188	0.64	0.28	
Significant Difference (19:1)		525	1.80	0.78	
Coefficient of Variation (%)		8.07	8.24	5.36	

Odds 19:1 = 1.979 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	13	5,766,553	63.74	1.83
Between replications	9	1,450,394	6.59	5.83
Remainder (Error)	117	352,395	4.12	0.77
Total	139			
Calculated F value		16.36**	15.47**	2.38**

** Exceeds the 1% point of significance (F=2.33)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1968

(10 x 10 Latin Square)
(Two-row plots)

Planted: September 25, 1967
Harvested: June 27-28, 1968

Variety	Description	Acre Yield		Sucrose	Harvest Count
		Sugar Pounds	Beets Tons	Percent	Number
U713H8	US H9B	9,340	29.92	15.6	128
F66-13H11	(563HO x 550) x 413	9,230	29.42	15.7	128
U713H4	US H9A	8,920	28.62	15.6	130
713H4	(562HO x 569) x 713	8,910	28.18	15.8	130
730TH33	716HO x 330T	8,820	29.45	15.0	120
664H8	US H7A	7,790	25.57	15.2	130
664H2	US H6	7,700	25.63	15.0	124
664H4	US H7	7,490	24.44	15.3	129
767H4	(562HO x 569) x 767	7,400	24.26	15.3	127
4539H4	US H8	7,200	23.24	15.5	130
General MEAN of all varieties		8,280	26.87	15.4	Beets
S. E. of MEAN		156	0.45	0.11	per
Significant Difference (19:1)		440	1.28	0.31	100'
Coefficient of Variation (%)		5.97	5.34	2.24	row

Odds 19:1 = 1.994 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES		
		Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	9	6,955,921	62.63	0.77
Between replications	9	526,528	6.80	0.24
Between columns	9	905,143	9.57	0.93
Remainder (Error)	72	244,068	2.06	0.12
Total	99			
Calculated F value		28.50**	30.40**	6.49**

** Exceeds the 1% point of significance (F=2.67)

VARIETY TESTS, SALINAS, CALIFORNIA, 1968

Location: USDA Agricultural Research Station

Soil type: Sandy loam.

Previous crops: Sugarbeets, 1965; fallow, 1966; purple vetch, 1967.

Fertilizer used: 656 lbs. per acre 0:10:10, preplant, broadcast and disced in before listing.
78 lbs. per acre actual N, preplant.
60 lbs. per acre actual N, sidedressed March 29, 1968.
76 lbs. per acre actual N, sidedressed May 15, 1968.
Source of nitrogen for all applications was ammonium sulfate.

Planting date: January 3-5, 1968.

Thinning date: February 26-28, 1968.

Harvest dates: September 4-25, 1968.

Irrigations: As required at 10-14 day intervals starting March 1, 1968.

Diseases and insects: Yellows viruses of minor importance in non-inoculated tests throughout season. Yield tests were sprayed with 1 3/4 pints per acre Meta Systox R on March 28 and April 27, 1968 for control of green peach aphid. The tests were sprayed with 1 - 1 1/2 pints per acre Diazanon on May 27, June 3 and July 8, 1968 for control of leaf miner.

Experimental design: All yield tests were of randomized block design with 10 replications. One test of 15 varieties was planted in two-row plots; plots 53 feet long. Varieties in five tests were planted in single-row plots; plots 53 feet long. Row spacing 28 inches wide.

Sucrose and quality analysis: From two samples per plot, of approximately ten roots each, at the sugar analytical laboratory, United States Agricultural Research Station, Salinas, California.

VARIETY TEST, SALINAS, CALIFORNIA, 1968

(10 replications of each variety)
(Two-row plots)

Planted: January 3, 1968
Harvested: September 9-10, 1968

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest Count Number
F66-13H11	(563HO x 550) x 413	14,590	45.31	16.1	0.6	592	202	1,491	645	146
713TH32	(754H4 x 716) x 413T	14,570	45.03	16.2	0.3	561	173	1,505	617	139
734H1	(562HO x 569 + 546) x 534	14,350	42.99	16.7	0.7	648	205	1,578	668	144
713TH34	760HO x 413T	14,260	45.26	15.8	0.5	541	194	1,809	675	141
713H4	(562HO x 569) x 713	14,210	42.26	16.8	0.1	647	165	1,517	644	143
730TH32	(754H4 x 716) x 330T	13,890	43.81	15.9	0.2	669	256	1,991	794	137
730TH33	716HO x 330T	13,820	42.43	16.3	0.2	803	208	1,744	809	134
613H4	(562HO x 569) x 613	13,720	42.06	16.3	0.8	729	195	1,652	745	143
464H11	(563HO x 550) x 464	13,720	41.26	16.7	1.2	647	206	1,582	669	147
U713H8	US H9B	13,710	41.74	16.4	0.9	651	179	1,494	663	146
U713H4	US H9A	13,580	40.30	16.9	0.3	643	171	1,480	636	146
767H4	(562HO x 569) x 767	13,360	38.97	17.2	0.3	633	205	1,642	924	144
664H4	US H7	13,110	38.62	17.0	0.3	709	210	1,696	709	145
664H8	US H7A	13,100	38.96	16.8	1.3	682	207	1,625	691	145
664H2	US H6	12,690	37.80	16.8	1.0	662	209	1,649	684	137
General MEAN of all varieties		13,780	41.79	16.5		655	199	1,630	705	Beets
Significant Difference (19:1)		662	2.28	0.48		NS	31	120	NS	per
Coefficient of Variation (%)		5.43	6.15	3.29		--	17.64	8.29	33.34	100'
Calculated F value		5.56**	9.24**	5.85**		NS	4.00**	10.70**	NS	row

** Exceeds the 1% point of significance (F=2.23)

VARIETY TEST, SALINAS, CALIFORNIA, 1968

(10 replications of each variety)
(Single-row plots)

Planted: January 3, 1968
Harvested: September 17-18, 1968

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest Count Number
713H39	(715H3 x 707) x 713 (mm)	15,250	45.71	16.7	1.9	708	233	1,697	727	142
713H36	(562HO x 707) x 713	15,240	45.63	16.7	0.3	856	220	1,788	826	142
713H38	(760H4 x 702) x 713 (mm)	14,950	45.33	16.5	0.7	900	246	1,838	879	141
613H24	(563HO x 760) x 613	14,800	44.51	16.6	1.9	800	190	1,755	786	140
744H8	(562HO x 546) x 544	14,740	44.14	16.7	0.9	716	265	1,639	730	144
744H4	(562HO x 569) x 544	14,710	45.54	16.2	0.4	812	288	1,808	847	143
Y704	YRS 534 x YRS 413	14,670	44.94	16.3	0.7	808	241	1,935	843	142
713H37	(562HO x 702) x 713	14,530	42.38	17.2	0.4	975	201	1,702	862	147
730TH35	(764H3 x 754) x 330T	14,440	44.26	16.3	0.2	1,012	258	2,066	998	143
Klein E	German var.	14,390	40.77	17.7	6.4	745	374	1,962	775	131
713H29	754HO x 713	14,280	44.18	16.2	0.0	889	223	1,916	889	144
713H30	(760H4 x 705) x 713 (mm)	14,230	42.04	17.0	2.0	768	223	1,605	739	146
744	YRS (330 x 234)	14,140	44.17	16.0	1.8	716	362	1,922	824	140
713	7th YR, 1st suc. sel. US 75	13,960	43.10	16.3	0.8	782	247	1,950	839	140
Vanguard	Russell YRS	13,780	43.43	15.9	0.0	1,035	662	2,254	1,152	138
737	YRS 663	13,770	41.90	16.4	1.0	697	448	2,135	843	145
534	Rietberg YRS	13,720	40.46	17.0	0.7	647	322	1,683	696	135
713H35	(764H3 x 754) x 713	13,670	41.95	16.3	0.4	798	231	1,806	816	142
713B	8th YRS US 75	13,570	41.95	16.2	0.1	801	268	2,034	864	148
F66-64	BRS 663	13,410	40.60	16.6	0.3	795	391	2,261	906	142
713A	8th YR, 2nd suc. sel. US 75	13,230	40.64	16.3	0.2	668	231	1,781	735	148
Y603	YRS 534	13,040	37.85	17.3	0.1	710	280	1,746	721	134
Klein AA	German var.	12,090	36.18	16.7	4.5	906	318	2,303	951	136
F57-68	US 75	11,460	34.37	16.7	0.9	806	319	2,044	857	131
General MEAN of all varieties		14,000	42.34	16.6		806	293	1,901	838	Beets per 100' row
Significant Difference (19:1)		838	2.83	0.49		164	50	149	117	
Coefficient of Variation (%)		6.80	7.57	3.34		23.16	19.39	8.90	15.84	
Calculated F value		9.30**	8.56**	5.57**		3.10**	32.08**	14.05**	5.75**	

** Exceeds the 1% point of significance (F 1.99)

VARIETY TEST, SALINAS, CALIFORNIA, 1968
Inoculated with yellows

(10 replications of each variety)
(Single-row plots)

Planted: January 5, 1968
Harvested: September 23-25, 1968

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest Count Number
Y704	YRS 534 x YRS 413	12,590	40.29	15.6	0.0	793	244	1,743	838	146
713H39	(715H3 x 707) x 713 (mm)	12,400	39.10	15.9	0.3	728	261	1,394	737	145
713H38	(760H4 x 702) x 713 (mm)	12,360	39.90	15.5	0.7	926	276	1,532	905	144
734H1	(562HO x 569 + 546) x 534	12,240	38.33	16.0	0.1	807	274	1,488	799	144
713TH34	760HO x 413T	12,170	41.70	14.6	0.3	614	290	1,750	789	142
744	YRS (330 x 234)	12,160	39.48	15.4	0.6	690	357	1,668	799	143
713H4	(562HO x 569) x 713 (mm)	12,140	39.47	15.4	0.0	1,023	248	1,550	974	145
713TH32	(754H4 x 716) x 413T	12,120	39.50	15.4	0.0	743	250	1,557	791	142
713H30	(760H4 x 705) x 713 (mm)	12,100	38.02	15.9	0.4	874	248	1,529	844	145
713H36	(562HO x 707) x 713	12,070	38.26	15.8	0.1	782	272	1,504	793	145
744H8	(562HO x 546) x 544	11,960	38.16	15.7	0.1	783	294	1,481	802	145
Y603	YRS 534	11,890	36.71	16.2	0.0	703	318	1,465	728	144
713H29	754HO x 713	11,870	38.71	15.3	0.1	773	250	1,580	818	141
F66-13H11	(563HO x 550) x 413	11,840	39.07	15.2	0.0	738	280	1,461	793	149
613H4	(562HO x 569) x 613	11,840	38.94	15.2	0.1	975	269	1,490	950	142
713B	8th YRS US 75	11,670	39.29	14.9	0.0	680	302	1,663	808	147
744H4	(562HO x 569) x 544	11,580	37.42	15.5	0.3	899	301	1,492	890	148
613H24	(563HO x 760) x 613	11,550	38.01	15.2	0.5	864	241	1,575	883	141
534	Rietberg YRS	11,520	35.19	16.4	0.0	717	358	1,511	743	139
713H37	(562HO x 702) x 713	11,310	36.60	15.5	0.1	1,065	259	1,581	1,006	141

VARIETY TEST, SALINAS, CALIFORNIA, 1968 continued
Inoculated with yellows

(10 replications of each variety)
(Single-row plots)

Planted: January 5, 1968
Harvested: September 23-25, 1968

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest Count Number
730TH33	716HO x 330T	11,220	36.99	15.2	0.1	1,062	343	1,679	1,063	135
713	7th YR, 1st suc. sel. US 75	11,180	35.67	15.7	0.2	828	266	1,726	863	139
713A	8th YR, 2nd suc. sel. US 75	11,110	35.19	15.8	0.0	825	256	1,647	835	142
U713H8	US H9B	11,090	36.29	15.3	0.1	835	265	1,445	843	148
U713H4	US H9A	11,070	36.47	15.2	0.1	1,031	269	1,484	980	146
713H35	(764H3 x 754) x 713	11,060	36.46	15.2	0.0	874	267	1,668	914	143
730TH35	(764H3 x 754) x 330T	10,600	35.51	14.9	0.0	1,142	304	1,835	1,145	143
737	YRS 663	10,590	34.46	15.4	0.1	647	461	1,830	823	144
730TH32	(754H4 x 716) x 330T	10,470	35.86	14.6	0.1	1,023	408	1,775	1,110	137
664H4	US H7	9,780	31.56	15.5	0.0	1,005	297	1,589	970	145
Vanguard	Russell YRS	9,360	34.48	13.6	0.1	1,138	805	1,839	1,382	138
F66-64	BRS 663	8,770	29.45	14.9	0.3	843	430	1,838	974	137
F57-68	US 75	6,620	22.67	14.6	0.3	1,075	431	1,739	1,141	131
General MEAN of all varieties		11,280	36.76	15.3		864	315	1,609	901	Beets
Significant Difference (19:1)		719	2.34	0.47		190	51	165	142	per
Coefficient of Variation (%)		7.23	7.24	3.44		24.92	18.28	11.65	17.87	100'
Calculated F value		22.19**	17.80**	10.30**		4.70**	33.74**	4.88**	7.86**	row

** Exceeds the 1% point of significance (F=1.74)

COOPERATIVE VARIETY ADAPTABILITY TRIAL
Salinas, California

(10 replications of each variety)
(Single-row plots)

Planted: January 3, 1968
Harvested: September 10, 1968

Variety	Acre Yield		Sucrose	Bolting	Harvest Count
	Sugar	Beets			
	Pounds	Tons	Percent	Percent	Number
US H9B	14,940	47.37	15.8	0.9	144
Sharpe's Klein E	14,840	46.91	15.9	5.1	139
Irish triploid	13,610	40.65	16.8	1.4	138
CS 42 (Canadian)	12,950	39.40	16.5	38.3	148
Irish diploid	12,850	38.43	16.7	0.4	145
A 291 (Canadian)	12,660	38.29	16.6	35.7	144
General MEAN of all varieties	13,640	41.84	16.4	13.7	Beets
Significant Difference (19:1)	663	2.34	0.36	4.7	per
Coefficient of Variation (%)	5.39	6.22	2.46	38.2	100'
Calculated F value	19.12**	25.93**	11.66**	122.8**	row

** Exceeds the 1% point of significance (F=3.45)

Similar tests were conducted in Alberta and Ireland but complete results are not yet available. These tests provided an opportunity to compare the performances of varieties developed in different latitudes and under different light intensities.

VARIETY TESTS, CLARKSBURG, CALIFORNIA, 1967-68

Summary of Fall & Spring Harvests

by American Crystal Sugar Company

Variety	Gross Sugar - KSL					Tonnage					Sucrose					Impurity Index				
	Fall	Rk	Spg.	Rk	% Inc.	Fall	Rk	Spg.	Rk	% Inc.	Fall	Rk	Spg.	Rk	% Inc.	Fall	Rk	Spg.	Rk	% Inc.
Am #5 Hybrid	3525	10	7706	8	118.6	15.46	8	26.79	7	73.2	12.63	11	15.64	12	23.8	663	5	536	9	19.1
509H1 x C-264	3897	2	7860	7	101.7	16.68	2	27.17	5	62.9	13.02	7	15.71	11	20.6	690	7	529	8	23.3
62-4T18 x 547H1	3570	9	8185	5	129.3	14.21	10	25.44	9	79.0	13.86	1	17.02	2	22.8	622	1	366	1	41.1
62-4T18 x 63-5HO	3595	8	7543	10	109.8	14.39	9	23.42	11	62.8	13.85	2	17.04	1	23.0	659	4	366	1	44.5
Am #2 Mono.	3181	11	7170	11	125.4	13.05	11	24.11	10	84.8	13.49	4	15.90	9	17.9	650	3	432	5	33.5
Am #2 Hyb. A	3149	12	6767	12	114.8	12.88	12	22.43	12	74.1	13.53	3	16.13	4	19.2	645	2	410	3	36.4
F66-13H4	3690	4	8231	3	123.1	15.98	5	27.74	3	73.6	12.94	8	16.05	7	24.0	721	8	504	7	30.1
F66-13H11	3645	5	8559	1	134.8	16.25	3	28.70	1	76.6	12.60	12	16.08	5	27.6	726	10	485	6	33.2
US H7	3629	6	7653	9	110.8	15.48	7	26.31	8	69.9	13.16	6	15.93	8	21.1	723	9	580	12	19.8
US H7A	3625	7	8196	4	126.1	15.85	6	27.76	2	75.1	12.89	9	16.10	6	24.9	736	11	554	11	24.7
463H11	3948	1	7902	6	100.1	17.53	1	27.22	4	55.3	12.70	10	15.79	10	24.3	744	12	538	10	27.7
74842 x 546H3	3866	3	8360	2	116.2	16.24	4	26.85	6	65.3	13.31	5	16.63	3	24.9	687	6	425	4	38.1

VARIETY TEST, CLARKSBURG, CALIFORNIA, 1967-68

Spring Harvest

by American Crystal Sugar Company

Variety	Gross Sugar - KSL Lbs.	Rk	% x̄	Tonnage Yield	Rk	% x̄	Sucrose %	Rk	% x̄	No. Roots 35'	Rk	% x̄	Impurity Index ppm/%	Rk	% x̄
Am #5 Hybrid	7706	6	98.17	26.79	7	102.41	15.64	12	96.73	38.0	12	95.72	536	9	112.39
509H1 x C-264	7860	7	100.14	27.17	5	103.87	15.71	11	97.16	41.2	2	103.78	529	8	110.93
62-4T18 x 547H1	8185	5	104.27	25.44	9	97.26	17.02	2	105.26	39.2	8	98.74	366	1	76.75
62-4T18 x 63-5H0	7543	10	96.09	23.42	11	89.53	17.04	1	105.39	39.4	7	99.24	366	1	76.75
Am #2 Monogerm	7170	11	91.34	24.11	10	92.17	15.90	9	98.34	38.9	10	97.98	432	5	90.59
Am #2 Hybrid "A"	6767	12	86.21	22.43	12	85.74	16.13	4	99.76	38.4	11	96.72	410	3	85.98
F66-13H4	8231	3	104.86	27.74	3	106.05	16.05	7	99.27	40.0	4	100.76	504	7	105.69
F66-13H11	8559	1	109.04	28.70	1	109.72	16.08	5	99.45	41.4	1	104.28	485	6	101.70
US H7	7653	9	97.49	26.31	8	100.58	15.93	8	98.52	40.7	3	102.52	580	12	121.62
US H7A	8196	4	104.41	27.76	2	106.12	16.10	6	99.57	39.9	5	100.50	554	11	116.17
463H11	7902	6	100.67	27.22	4	104.06	15.79	10	97.66	39.6	6	99.75	538	10	112.82
7484 2 x 546H3	8360	2	106.51	26.85	6	102.64	16.63	3	102.85	39.2	8	98.74	425	4	89.12
General Mean	7855			26.16			16.17			39.7			477		
LSD (.05)	398			1.24			.29			—			34		
F. Value	—			18.94**			21.28**			**			38.23**		
C. V. %	5.41			5.07			1.91			6.05			7.57		

Variance Table a/

Source of Variation	D/F	Mean Squares (variance) Tons Beets	Percent Sucrose	No. Roots (35')	Impurity Index
Replications	8	18.3393	0.3325	25.250	8,433
Varieties	11	33.3162	2.0345	9.818	49,852
Error	88	1.7585	0.0956	5.772	1,304
Total	107	6.2425	0.3126	7.6448	6,576

a/ For gross sucrose-KSL SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs. beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{Mean \% sucrose})}}$$

Plot size: 2 row plots, 35 feet long, 22 inch rows.
Design: 12 entries, 9 replications in Randomized Block.
Planted: June 13, 1967
Harvested: March 20, 1968

VARIETY TEST, CLARKSBURG, CALIFORNIA, 1968

Fall Harvest

by American Crystal Sugar Company

Variety	Description	Gross Sugar - KSL Lbs.	Rk	% $\bar{x}$	Tonnage Yield	Rk	% $\bar{x}$	Sucrose %	Rk	% $\bar{x}$	Impurity Index ppm/%	Rk	% $\bar{x}$
F66-13H4	(562HO x 569(x 413 V.Y. Res.	8063	2	108.36	27.69	4	106.30	14.56	4	101.89	1199	3	91.95
F66-13H11	(563HO x 550) x 413 V.Y. Res.	7468	7	100.37	27.74	3	106.49	13.46	12	94.19	1347	9	103.30
US H7	(562HO x 569) x 663	7425	8	99.79	26.50	7	101.73	14.01	11	98.04	1383	11	106.06
US H7A	(562HO x 546) x 663	7548	5	101.44	26.32	8	101.04	14.34	6	100.35	1292	6	99.08
US H9A	(562HO x 569) x 413 V.Y. Res.	7736	4	103.97	27.55	5	105.76	14.04	10	98.25	1269	5	97.32
Am #2 Hybrid "B"	CTR-LSR-RRR Monogerm	7145	10	96.02	24.42	10	93.74	14.63	2	102.38	1108	1	84.97
7484 2 x 546H3	Klein Hybrid Multigerm	7310	9	98.24	25.49	9	97.86	14.34	6	100.35	1310	7	100.46
62-4T18 x 547H1	Triploid	6979	11	93.80	23.90	11	91.75	14.60	3	102.17	1382	10	105.98
569H3 x 58-205-0	Non-Bolting CTR x Am #5 Sel.	7498	6	100.77	26.55	6	101.92	14.12	9	98.81	1340	[illegible]	102.76
Am #1 Monogerm	62-GH #2-1-0	5788	12	77.79	19.54	12	75.01	14.81	1	103.64	1596	12	122.40
5HO x 413	ACS [illegible] x Virus Yellows Sel.	8187	1	110.03	28.87	1	110.83	14.18	[illegible]	99.23	1226	4	94.02
US H9B	546H3 x C-413	8062	3	108.35	28.09	2	107.84	14.35	5	100.42	1198	2	91.87
General Mean		7445			26.05			14.29			1304		
LSD (.05)		706			2.10			.71			199		
F. Value		--			11.38**			2.04*			3.03**		
C. V. %		10.12			8.63			5.30			16.35		

Variance Table a/

Source of Variation	D/F	Mean Squares (variance) Tons Beets	Percent Sucrose	Impurity Index
Replications	8	1480.00	2.0475	159,980
Varieties	11	1998.44	1.1691	137,898
Error	88	175.61	0.5736	45,481
Total	107	4211.76	0.7450	63,529

a/ For gross sucrose-KSL SE lbs. sucrose = [illegible] lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{Mean lbs. beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{Mean \% sucrose})}}$$

Plot size: 2 row plots, 35 feet long, 22 inch rows.
Design: 12 entries, 9 replications in Randomized Block.
Planted: March 26, 1968
Harvested: September 3, 1968

1968 TULARE WINTER PLANT VARIETY TEST

Variety	Description	Gross Sugar Lb/A	Tons Beets /A	% Sugar	Beets /100'	% Bolters
734H1	(546H3x534) and (569H3x534)	10599	34.33	15.47	166	
F66-13H11	550H4x413(WL6454)	10508	35.32	14.93	171	
713H36	(562x707)x713	10203	34.27	14.93	168	
744H4	569H3x544	10102	33.06	15.28	176	
744H8	546H3x544	10022	34.12	14.70	168	
USH9B	546H3x413(WL7326)	9898	32.94	15.06	168	0.1
USH9A	569H3x413(WL7279)	9468	30.74	15.45	174	
USH7	569H3x644(WL6431)	8979	30.18	14.87	175	
USH8	569H3xNB7(WL6360)	8663	28.90	15.07	171	
Test Mean		9279	30.68	15.20	171	1.5
SE Mean		251	.88	.24		
SE Mean/Test Mean (%)		2.7	2.86	1.59		
LSD (5%)		696.7	2.43	.67		

VARIANCE TABLE

Source	D.F.	Mean Squares Tons Beets	% Sugar
Replication	8	162.41	20.02
Variety	35	67.59	.99
Error	280	6.94	.53
Total	323		
Calc. F. Value		9.73**	1.89*

*Significant (.05 level)
**Highly Significant (.01 level)

Plot Size: 2-30 inch rows x 50 feet
Design: Lattice with 36 entries 9 replications
Harvest: Yield-entire plot; Sucrose 2-25 samples per plot.

Planted: January 23, 1968
Harvested: July 27, 1968
Cooperator: Hercal Corp., Tulare, California

Remarks: Excellent stand. Good test except for lack of uniform soil conditions. No rot or disease were evident at harvest.

Extracted from a test of 36 varieties.

1968 TULARE FALL PLANT VARIETY TEST

Variety	Description	Gross Sugar Lb/A	Tons Beets /A	% Sugar	Beets /100'	% Bolters
USH9B	546H3xC413(WL7326)	8861	32.45	13.69	170	0.3
713H36	(562HOx707)xC713	8815	32.72	13.48	157	0.6
713H39	(715H3x707)xC713	8610	31.84	13.57	155	0.8
713H35	(764H3x754)xC713	8517	31.52	13.53	166	0.3
713H4	569H3xC713	8480	30.41	12.99	171	0.1
F66-13H11	550H4xC413	8420	31.34	13.49	156	1.0
USH9A	569H3xC413(WL7279)	8396	30.78	13.78	168	0.1
713H37	(562HOx702)xC713	8107	30.26	13.43	149	1.1
713H29	754HOxC713	8084	30.02	13.48	172	0.1
730TH32	(754H4x716)x730T	7844	30.25	13.04	143	0.6
730TH33	716HOx730T	7824	30.04	13.05	143	0.1
USH7A	664H8(546H3x664)	7413	27.43	13.63	160	1.4
USH8	569H3xNB7(WL6360)	7312	26.18	14.00	175	2.2
USH7	664H4(569H3x664)	7098	26.03	13.69	170	1.0
Test Mean		7845	28.78	13.69	165	1.4
SE Mean		277	1.10	.21		
LSD (5%)		768.4	3.04	.58		
SE Mean/Test Mean (%)		3.5	3.82	1.54		

VARIANCE TABLE

Source	D.F.	Mean Squares Tons Beets	Mean Squares % Sugar
Replication	8	133.69	4.23
Variety	29	44.64	1.42
Error	232	10.85	.40
Total	269		
Calc. F. Value		4.11**	3.56**

**Highly significant (.01 level)

Plot Size: 2-30 inch rows x 50 feet
Design: Lattice with 30 entries 9 replications
Harvest: Yield - entire plot; Sucrose - 2-25 lb. samples per plot.

Planted: November 27, 1967
Harvested: August 2, 1968
Cooperator: Menezes Brothers, Tulare, California

Remarks: No disease or rot was in evidence. Bolting results may be affected by late emergence.

Extracted from a test of 30 varieties.

1968 FAMOSO WINTER PLANT VARIETY TEST

Variety	Description	Gross Sugar Lb/A	Tons Beets /A	% Sugar	Beets /100'	Curly Top
USH9A	569H3x413(WL7279)	8705	45.32	9.56	158	4.8
USH7A	664H8	8660	47.12	9.24	155	11.2
713H36	(562x707)x713	8345	43.94	9.50	159	2.3
USH9B	546H3x413(WL7326)	8308	43.83	9.47	156	5.4
USH7	569H3x664(WL6431)	8262	42.79	9.61	158	15.1
744H8	546H3x544	7986	42.23	9.45	158	9.8
F66-13H11	550H4x413(WL6454)	7793	42.55	9.14	157	3.0
USH8	569H3xNB7(WL6360)	7135	40.97	8.68	154	10.4
Test Mean		7933	42.36	9.34	156	8.4
SE Mean		373	1.49	.26		
SE Mean/Test Mean (%)		4.7	3.52	2.83		
LSD (5%)		1043.3	4.18			

VARIANCE TABLE

Source	D.F.	Mean Squares Tons Beets	Mean Squares % Sugar
Replication	8	69.71	2.55
Variety	15	47.86	1.00
Error	120	20.06	.63
Total	143		
Calc. F. Value		2.39**	1.59NS

**Highly significant (.01 level)
NS=Non-Significant

Plot Size: 2-22 inch rows x 50 feet
Design: Lattice with 16 entries 9 replications
Harvest: Yield - entire plot; Sucrose 2-25 lb. samples per plot.

Planted: January 30, 1968
Harvested: October 2, 1968
Cooperator: Bernard Bone, Buttonwillow, California

Remarks: Good stand except for skips that were cultivated out. Curly top infestion was noted and evaluated. Leaf spot was observed to be uniform and light. Poor sugar content is noted. Variation in yield over the test make results questionable.

Extracted from a test of 16 varieties.

1968 TRACY SPRING HARVEST VARIETY TEST

Variety	Description	Gross Sugar Lb/A	Tons Beets /A	% Sugar	Beets /100'	% Bolters
534H11	(563HOx550)x234	7959	25.99	15.37	115	.23
F66-13H11	3550H4x413	7026	24.50	14.46	116	.28
413H8	(562HOx546)x413	6957	23.84	14.61	107	.23
USH7	L6431	6660	23.37	14.21	112	.12
544H11	(563HOx550)x544	6654	23.42	14.28	107	.27
463H11	(563HOx550)x663	6616	22.80	14.57	118	.11
463H12	(563HOx546)x663	6426	21.91	14.68	109	.09
463H8	(562HOx546)x663	6287	21.94	14.35	108	.12
USH8	L5517	5027	17.35	14.54	108	.08
Test Mean		6282	21.89	14.36		
SE Mean		282	.83	.34		
LSD (5%)		788	2.32	.94		
SE Mean/Test Mean (%)		4.5	3.81	2.35		

VARIANCE TABLE

Source	D.F.	Mean Squares	
		Tons Beets	% Sugar
Replication	8	18.95	8.29
Variety	29	27.06	2.00
Error	232	6.25	1.02
Total	269		
Calc. F. Value		4.33**	1.96**

**Highly Significant (.01 level)

Plot Size: 2-30 inch rows x 50 feet
Design: 5 x 6 Rectangular Lattice
Harvest: Yield - entire plot; Sucrose 2-25 lb. samples per plot.

Planted: June 21, 1967
Harvested: April 16, 1968
Cooperator: John Paulson, Tracy, California

Remarks: Good test. Some bolting noted and evaluated. In general stand was only fair to poor because of late plantings.

Extracted from a test of 30 varieties.

1968 IMPERIAL VALLEY U.S.D.A. VARIETY TEST

Variety	Description	Gross Sugar Lb/A	Tons Beets /A	% Sugar	Beets /100'
USH7	(562HOx569)x264	6744	24.01	14.04	161
713H36	(562HOx707)x713	6568	23.46	14.01	153
713H4	(562HOx569)x713	6546	23.14	14.13	158
730TH32	(754H4x716)x730T	6538	23.15	14.07	153
USH9A	(562HOx569)x413	6526	23.09	14.12	152
USH8	(562HOx569)xNB7	6496	23.17	14.04	159
USH9B	(562HOx546)x413	6449	23.42	13.75	152
USH7A	(562HOx546)x264	6421	21.83	14.63	161
Test Mean		6536	23.16	14.10	157
SE Mean		266	.76	.30	
SE Mean/Test Mean (%)		4.1	3.29	2.09	

VARIANCE TABLE

Source	D.F.	Mean Squares	
		Tons Beets	% Sugar
Replication	7	9.03	1.48
Variety	7	3.03	.48
Error	49	4.63	.70
Total	63		
Calc. F. Value		.65NS	.69NS

NS=Non-significant

Plot Size: 2-32 inch rows x 50 feet
Design: Randomized Complete Block with 8 entries 8 replications
Harvest: Yield - entire plot; Sucrose - 2-25 lb. samples per plot.

Planted: September 26, 1967
Harvested: July 9, 1968
Cooperator: Nelson Correll, Calipatria, California

Remarks: Test had to be replanted. Validity of test is questionable since no difference between varieties was obtained. Test "appeared" to be good.

1968 IMPERIAL VALLEY EARLY HARVEST VARIETY TEST

Variety	Description	Gross Sugar Lb/A	Tons Beets /A	% Sugar	Beets /100'
F66-13H11	550H4xC413	7084	26.04	13.59	130
613H4	569H3xC613	7029	26.31	13.36	144
USH9A	569H3xC413(WL7279)	6815	25.31	13.48	150
713H38	702H24xC713	6760	25.21	13.43	130
713H4	569H3xC713	6746	24.69	13.68	144
713H39	707H21xC713	6705	25.51	13.14	138
713H37	702H3xC713	6655	24.55	13.57	133
USH9B	546H3xC413	6638	24.77	13.41	140
USH7	WL6273	6442	23.52	13.69	140
713H36	707H3xC713	6362	23.93	13.33	142
713H29	754H0xC713(Monogerm)	6351	24.34	13.06	136
713H35	754H28xC713(Monogerm)	6213	24.00	12.98	138
USH8	WL6360	6210	22.77	13.61	141
730TH33	716H0x730T(Monogerm)	6130	24.05	12.75	107
767H4	569H3x(264Tx586T)	5876	21.25	13.82	125
Test Mean		6512	23.87	13.66	135
SE Mean		178	.54	.20	
SE Mean/Test Mean (%)		2.7	2.28	1.43	
LSD (5%)		492.5	1.51	.54	

VARIANCE TABLE

Source	D.F.	Mean Squares Tons Beets	% Sugar
Replication	8	16.63	5.83
Variety	35	27.41	1.54
Error	280	2.66	.34
Total	323		
Calc. F. Value		10.31**	4.48**

**Highly Significant (.01 level)

Plot Size: 2-30 inch rows x 50 feet
Design: Lattice with 36 entries 9 replications
Harvest: Yield - entire plot; Sucrose 2-25 lb. samples per plot.

Planted: September 13, 1967
Harvested: April 26, 1968
Cooperator: Don Cox, Imperial Valley, California

Remarks: Good test.

Extracted from a test of 36 varieties

DATA ON USDA VARIETIES TESTED BY SPRECKELS SUGAR COMPANY 1968

TEST AREAS:	SPRECKELS			SOLEDAD		
Variety	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
713H4	5.232	35.46	14.7			
713H37	5.197	35.74	14.5			
US H9A	5.134	35.17	14.6			
713H39	5.119	34.95	14.6			
613H4	5.112	35.34	14.4			
744H4	5.045	34.46	14.6			
US H7A	4.895	33.35	14.7			
US H9B	4.740	32.84	14.4	4.533	32.35	13.9
744H8	4.707	33.44	14.1			
767H4	4.677	31.14	15.0			
US H7	4.586	30.24	15.2	4.361	30.55	14.3
730TH33	4.581	32.29	14.2			
713H29	4.527	32.18	14.7			
713H35	4.495	30.65	14.7			
General Mean	4.824	32.98	14.6	4.751	32.88	14.4
LSD @ P = .05	0.387	2.26	0.7	0.599	3.28	0.8
LSD @ P = .01	0.512	3.00	NS	0.799	NS	1.1
S.E. of Mean	0.138	0.818	0.25	0.210	1.158	0.285
S.E. in % of Mean	2.86	2.48	1.73	4.42	3.52	1.98
Varieties in Test	12			8		
Number of Reps	8			8		
Planting Date:	January 4, 1968			January 16, 1968		
Harvest Date:	September 5, 1968			September 18, 1968		

DATA ON USDA VARIETIES TESTED BY SPRECKELS SUGAR COMPANY - 1968, Con't.

TEST AREAS:	KING CITY			GONZALES			SAN LUCAS			GREENFIELD		
Variety	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
713H4												
713H37												
US H9A												
713H39												
613H4												
744H4												
US H7A												
US H9B	5.926	37.57	15.7	7.082	46.45	15.2	4.676	36.15	12.9	5.633	42.00	13.4
744H8												
767H4												
US H7	4.920	30.92	15.8	6.535	42.76	15.3	4.486	35.43	12.7	5.436	38.81	14.0
730TH33												
713H29												
713H35												
General Mean	5.425	34.65	15.0	6.881	45.70	15.1	4.270	33.65	12.7	5.479	40.16	13.6
LSD @ P = .05	0.462	2.92	NS	NS	NS	NS	NS	4.06	0.7	NS	3.30	0.6
LSD @ P = .01	0.616	3.89	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S.E. of Mean	0.162	1.025	0.187	0.268	1.57	0.233	0.208	1.427	0.254	0.187	1.163	0.204
S.E. in % of Mean	2.99	2.96	1.20	3.89	3.44	1.54	4.88	4.24	2.00	3.41	2.90	1.50
Varieties in Test		8			8			8			8	
Number of Reps.		8			8			8			8	
Planting Date:	January 5, 1968			December 29, 1968			January 22, 1968			February 5, 1968		
Harvest Date:	October 24, 1968			September 19, 1968			September 24, 1968			September 17, 1968		

DATA ON USDA VARIETIES TESTED BY SPRECKELS SUGAR COMPANY
1968

TEST AREAS:	MENDOTA			ARBUCKLE		
Variety	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
US H9A	6.143	43.47	14.2	4.654	28.58	16.3
744H4	5.775	41.03	14.2			
713H4	5.738	41.76	13.9			
744H8	5.734	40.50	14.2			
US H9B	5.613	41.48	13.5			
767H4	5.462	39.67	13.8			
US H7	5.170	38.24	13.5	4.089	24.69	16.6
US H8	4.729	35.10	13.5	4.061	24.50	16.6
664H8				4.136	25.23	16.4
4539H12				3.511	22.06	15.9
General Mean	5.411	39.06	13.9	3.948	24.30	16.2
LSD @ P = .05	0.438	3.63	0.64	0.352	1.98	0.46
LSD @ P = .01	0.581	4.47	NS	0.449	2.52	0.59
S.E.of Mean	0.156	1.20	0.228	0.138	0.775	0.182
S.E.in % of Mean	2.88	3.07	1.64	3.50	3.19	1.12
Varieties in Test		16			16	
Number of Replications		6			6	
Planting Date:	March 6, 1968			June 13, 1967		
Harvest Date:	September 11, 1968			April 18, 1968		

VARIETY TEST, SALINAS, CALIFORNIA, 1968

(10 replications of each variety) — By Union Sugar Division

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	N PPM	Na PPM	K PPM	Imp. Index	Harvest Count Number
730TH33	716HO x 330T	9,840	29.27	16.8	440	489	1,046	520	102
734H1	(562HO x 569 + 546) x 534	9,680	28.47	17.0	460	469	973	511	103
713TH34	760HO x 413T	9,430	28.87	16.3	422	441	1,052	514	101
730TH32	(754H4 x 716) x 330T	9,230	27.69	16.7	447	528	1,122	548	98
F66-13H11	(563HO x 550) x 413	9,080	27.97	16.2	447	545	920	538	103
713TH32	(754H4 x 716) x 413T	8,900	27.32	16.3	432	406	945	499	99
U713H8	US H9B	8,780	26.65	16.4	432	502	910	510	101
613H4	(562HO x 569) x 613	8,720	26.34	16.5	442	413	1,010	509	103
713H4	(562HO x 569) x 713	8,590	25.64	16.7	434	464	975	504	101
767H4	(562HO x 569) x 767	8,560	25.04	17.0	437	578	940	514	97
U713H4	US H9A	8,180	24.90	16.4	447	455	1,000	522	111
664H8	US H7A	8,150	24.25	16.7	439	569	971	528	97
464H11	(563HO x 550) x 464	8,120	25.12	16.0	445	748	893	588	100
664H4	US H7	7,120	21.21	16.7	443	615	1,006	547	106
General MEAN of all varieties		8,740	26.34	16.6	440	516	983	525	Beets per 100' row
Significant Difference (19:1)		1,034	2.81	0.46	NS	132	96	44	
Coefficient of Variation (%)		13.36	12.03	3.15	6.29	28.83	11.08	9.48	
Calculated F value		3.76**	4.71**	3.32**	NS	3.79**	3.29**	2.27*	

* Exceeds the 5% point of significance (F=1.81). ** Exceeds the 1% point of significance (F=2.29).

Remarks: A variety test of 14 varieties, in a randomized block design, was included in a 60-acre field of sugarbeets on the Elmer Abeloe Ranch, Salinas, California. Plots 60 feet long were planted on double-row beds with 40-inch centers. A preplant herbicide treatment of 52 ounces of Tillam in 45 gallons of water per acre was incorporated in 22-inch wide strips on the beds. The test plot was planted January 29, 1968 and thinned March 26, 1968. The field was sprayed with Meta-systox R April 22, 1968 for control of green peach aphid. Sprinkler irrigations, applied at 10-day intervals, were started April 24, 1968. The total fertilizer used consisted of 206 lbs. of actual N and 160 lbs. of P, as P_2O_5, applied preplant, one sidedress application and metered through the irrigation system. The test plot was harvested October 30-31, 1968. Sucrose and quality determinations were made at the U.S. Agricultural Research Station, Salinas, California. Test design, seed, and analysis of results supplied by the U.S. Research Station.

Virus diseases were minor throughout the 60-acre field. A moderately extensive nematode infestation reduced yields in the area containing the test plot. The field was mowed at a height of 4-6 inches above the beet crowns in mid-July to eliminate tall weeds interfering with water distribution.

By Union Sugar Division

VARIETY TESTS, IMPERIAL VALLEY, CALIFORNIA, 1967-68

Test 1:--A randomized block experiment of six varieties with eight replications was included in a field of sugarbeets located at Evergreen Canal, Gate 23-A, Lerno Bros. Ranch, El Centro, California. The field was a silty clay loam soil type and was in alfalfa four years prior to sugarbeets. Plots 60 feet long were planted on double-row beds with 40-inch centers. The variety test was planted October 25, 1967 and thinned December 16, 1967. The field was sprayed twice, in late October and early November, with 15 ounces per acre Methyl parathion for control of desert flea beetle and striped cabbage beetle. During the growing season the field received 3.87 inches rainfall and was irrigated 12 times by furrow. Fertilizer use totaled 280 lbs. per acre N and 62 lbs. per acre actual P applied as preplant, as a sidedress application and in the irrigation water. The test plot was harvested July 16, 1968.

Test 2:--The Test 1 experiment was repeated in a field of sugarbeets located at Canal G, Gate 6-A, William Young Ranch, Imperial, California. Soil type was a sandy loam. Previous crops were cotton in 1965-66 and alfalfa in 1963-64. Plot length and row spacing was the same as for Test 1. An application of Roneet herbicide at 4 lbs. per acre caused severe seedling damage and necessitated replanting the field. The variety test was replanted October 13, 1967 and thinned December 20, 1967. The field was sprayed once with Methyl parathion, at a rate of 15 ounces per acre, for control of striped cabbage beetle. Granular 10 percent Thimet was applied to the field in January, 1968, for control of green peach aphid. During the growing season the field was irrigated 13 times by furrow and received 3.87 inches of rainfall. Fertilizer use totaled 330 lbs. per acre N and 59 lbs. per acre actual P applied as preplant, as a sidedress application and in the irrigation water. The test plot was harvested July 19, 1968. Because of spotty stands, only a 10-foot section of each plot was harvested for yield and sucrose determinations.

Remarks:--Sucrose determinations were made by Union Sugar Division, Imperial Valley Tare Laboratory, El Centro, California.

Yellows and curly top virus infection was light in both Test 1 and Test 2.

Experimental design and seed supplied by U.S. Agricultural Research Station, Salinas, California. Tests were planted, observed throughout season, and harvested by K. D. Beatty, Southwestern Irrigation Field Station, Brawley, California, in cooperation with Union Sugar Division. Results analyzed by K. D. Beatty.

Variety Test, Brawley, California, 1968
Union Sugar Comp. Cooperative Test

Lerno Bros., El Centro
(6 x 8 randomized block
(one, double-row 40" bed per plot)

Planted: October 25, 1967
Harvested: July 16, 1968

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Number
U713H8	USH9B	11,015	33.40	16.50	147
U713H4	USH9A	10,722	32.72	16.40	148
713H35	(764H3 x 754) x 713	10,343	32.23	16.06	134
664H8	USH7A	10,287	31.95	16.09	143
664H4	USH7	10,243	31.69	16.17	152
664H2	USH6	9,817	30.20	16.28	143
General MEAN of all varieties		10,405	32.03	16.25	Beets per 100' of row
Standard Error of MEAN		180.0	0.44	0.15	
Significant Difference (19:1)		517.1	1.25	NS	
Coefficient of Variation (%)		4.89	3.84	2.65	

Odds 19:1 = 2.0315 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	5	1,380,352	9.362	0.24
Between replications	7	352,883	5.943	2.21
Remainder (Error)	35	259,252	1.515	0.186
Total	47			
Calculated F value		5.324**	6.180**	1.29(NS)

** Exceeds the 1% point of significance (F = 3.6064)

Sugarbeet Variety Test - Brawley, California - 1968
Cooperative Test - Union Sugar Company

Bill Young Farm
(6 varieties, 8 replications)
(one, double-row - 40" bed per plot - 60' long)

Planted: October 13, 1967
Harvested: July 19, 1968

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Harvest Count Beets per 100' of row Number
U713H8	USH9B	10,026	35.16	14.31	163
U713H4	USH9A	9,729	34.17	14.28	170
713H35	(764H3 x 754) x 713	8,795	32.03	13.71	158
664H8	USH7A	8,458	29.88	14.14	167
664H4	USH7	8,344	30.50	13.67	166
664H2	USH6	7,510	27.08	13.90	180
General MEAN of all varieties		8,810	31.47	14.00	
Standard Error of MEAN		318	1.15	0.21	
Significant Difference (19:1)		915	3.31	NS	
Coefficient of Variation (%)		10.22	10.37	4.19	

Odds 19:1 = 2.0315 x $\sqrt{2}$ x Standard Error of MEAN

VARIANCE TABLE

Variation due to	Degrees of Freedom	MEAN SQUARES Gross Sugar	Tons Beets	Percent Sucrose
Between varieties	5	6,964,873	70.37	0.64
Between replications	7	1,602,693	10.30	2.61
Remainder (Error)	35	811,164	10.64	0.344
Total	47			
Calculated F value		8.586**	6.61**	1.86 NS

** Exceeds the 1% of significance

A CONVENIENT PLOT SEEDER FOR SUGARBEET TRIALS

I. O. Skoyen and J. S. McFarlane

Good seed distribution is essential to the establishment of adequate plant populations in sugarbeet nursery plots or variety yield trials. Hand-drop seeding can be used for planting short-row plots but seed distribution depends on individual proficiency. At the U.S. Agricultural Research Station, Salinas, California, plot rows 40 feet or less in length have been seeded by hand dropping seed through funnels and Planet Jr. planter shoes. For seeding longer plot rows the Planet Jr. hoppers have been used. This requires the time consuming procedures between plots of emptying excess seed into bags and making seed plate adjustments to accommodate the next seed lot to be seeded. A two-row cone feed seeder adapted to a wide range of plot row lengths and with good seed distribution in the row has been constructed.

The seeder incorporates modifications of cone feed seeders designed by Mr. M. A. Berg, U.S.D.A., Bozeman, Montana and Dr. J. M. Poehlman, University of Missouri, Columbia. Special brackets constructed for the cone feed units permit attachment to standard I. H. C. McCormick 185 planters by removing the original seed boxes (Figures 1 and 2). The cone feed units were obtained from Seedrite Equipment Company, 204 South Ninth Street, Bozeman, Montana. Seed is directed into the planter drop tubes by specially constructed funnels fastened to the seed spout of the cone housings (Figures 1 and 2).

Seed placed in the funnel resting in a guide over the cone apex is distributed on the cone seed plate by lifting the funnel in the guide (Figure 3). A small gate positioned across the seed plate diverts seed into the drop tube as the cone makes a full rotation (Figure 3). After seeding a plot, any seed remaining on the seed plates or cone housing rims is quickly removed by sweeping with a small brush.

Plot lengths up to 86 feet can be seeded with the combinations of feed shaft and drive shaft sprockets shown in the graph (Figure 5). Easily installed shaft extensions permit mounting the sprocket sizes required to seed a given plot length (Figures 2 and 4). The extensions are machined so that slotted holes in the sprocket hubs, which are the same size as those of the original sprockets, fit snugly on the shaft extensions. The sprockets are held in place with cap screws. Number 41 link chain was used because of easily available sprocket sizes and chain length adapters.

Exchanging the cone seeders with the hoppers and replacing the original sprockets and chain converts the I. H. C. 185 planter units to original equipment for spaced-seed planting or seeding long border rows.

The use of the cone seeder arrangement described requires at least a three-foot alleyway between blocks because of the long seed drop, about 20 inches. The planter should be stopped so that the disc openers must travel at least two feet in the alleyway before entering the next plot to be seeded. This insures that seed is dropping into the planting furrows as the next plot is entered.

The I. H. C. 185 planter units are attached to one of the toolbars of the planter frame (Figures 3 and 4). An A-frame clamped to the front toolbar of the planter frame permits attachment to a tractor equipped with a three-point hitch. The planter is raised and lowered by the tractor hydraulic system. A cable attached to the tractor and at the rear of the planter frame holds the planter horizontal during raising and lowering (Figure 4).

The planter frame was assembled exclusively with toolbar clamps to provide convenient adjustments when planting different row spacings. Gauge wheels provide adjustment for variations in bed height and, in conjunction with depth bands on the disc furrow openers, increases control of seeding depth (Figure 4).

The planter design provides for two attendants during seeding (Figure 4). Each attendant operates a planter unit on single-row beds or two units on double-row beds. The pipe frame and the pipe stubs shown in Figure 4 provide the carrier for the heavy wire rods on which are strung the seed envelopes needed to plant a row of plots. Seed envelopes arranged in planting order are placed on the wire rods in the laboratory. The rods are also a convenient means of carrying the seed envelopes to the field and insures that the envelopes remain in proper seeding order.

Wind effects on the seed distribution around the seed plate are minimized by a six-inch high rim fastened to the outside rim of the cone seeder (Figures 1 and 3). Tapered flexible plastic baskets of the proper size were used to construct the rim extensions.

The planter incorporates only two cone-feed units at present but is readily adapted to four or more units by installing longer toolbars and strengthening the planter frame by adding one or two lengthwise frame supports (Figure 4).

Rate of seeding can be controlled within limits by the amount of seed distributed around the seed plate. However, when the cone rotates very slowly, as occurs in seeding long-plot rows, seed distribution on the seed plate must be dense enough to insure continuous dropping of seed into the drop tube. Sparse seed distribution on the seed plate could cause some sliding of the seedballs rather than falling into the tube. One means of adapting the cones to seeding limited quantities of seed would be to narrow the seed plate width by installing triangular shaped rings on the cone edge. A seed plate width equivalent to the diameter of 1-3 seedballs might be possible. A one-seedball-wide seed plate surface should permit planting essentially a single seed at the time. The distance between seedballs in the row would be determined by the frequency of drop, and speed of travel.

Figure 1. Construction of the bracket, slotted pipe flange, and seed drop funnel which permits attaching cone feed unit in same position on IHC 185 planter as original hopper.

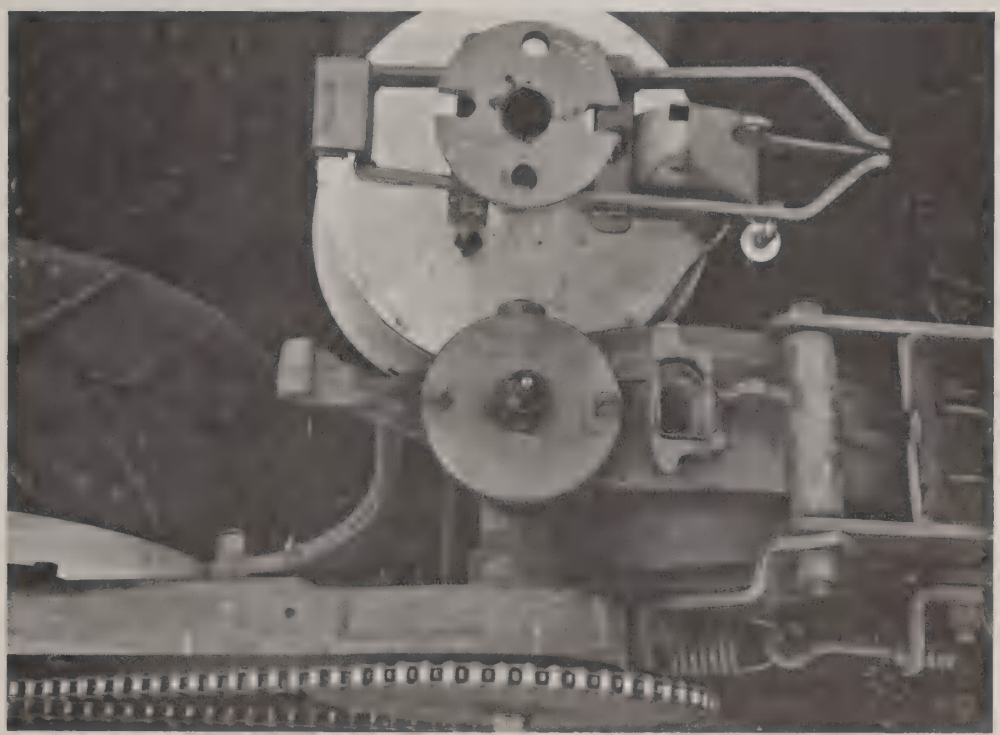


Figure 2. View of IHC 185 planter unit with original hopper removed and showing base of cone feed unit which fits interchangeably with original hopper.

Figure 3. View of seed distribution on seed plate after raising the funnel from its center guide allowing the seed to flow over the cone. During seeding operation the funnel need be raised only enough to allow all seed to empty out.

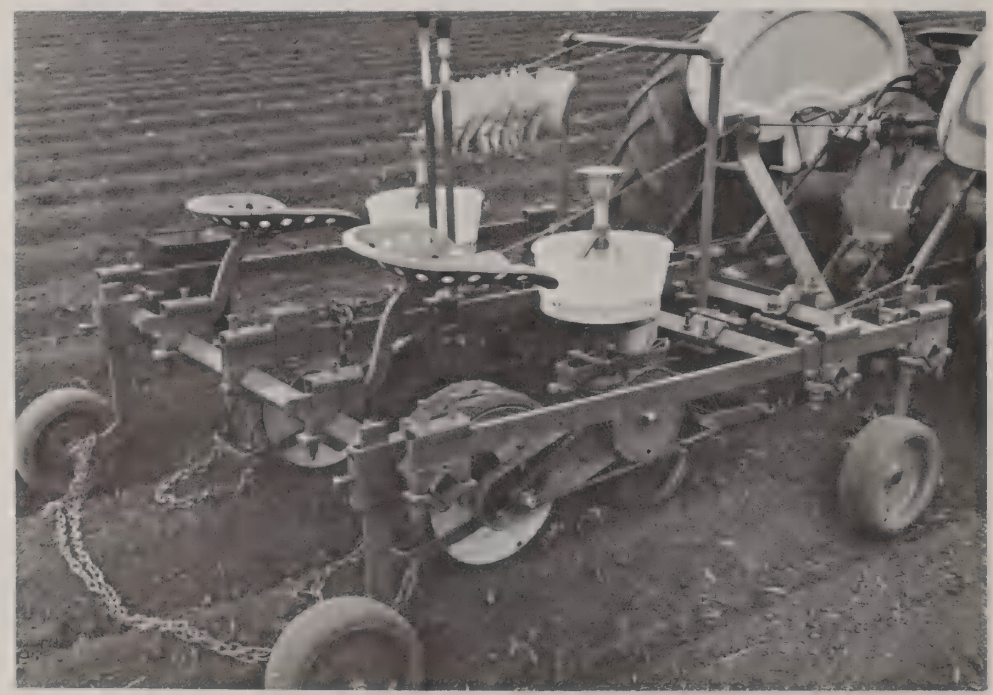


Figure 4. View of entire planter assembly showing attendant seating, seed envelopes on wire rods arranged for planting, and sprocket arrangement for seeding a 53 foot plot row.

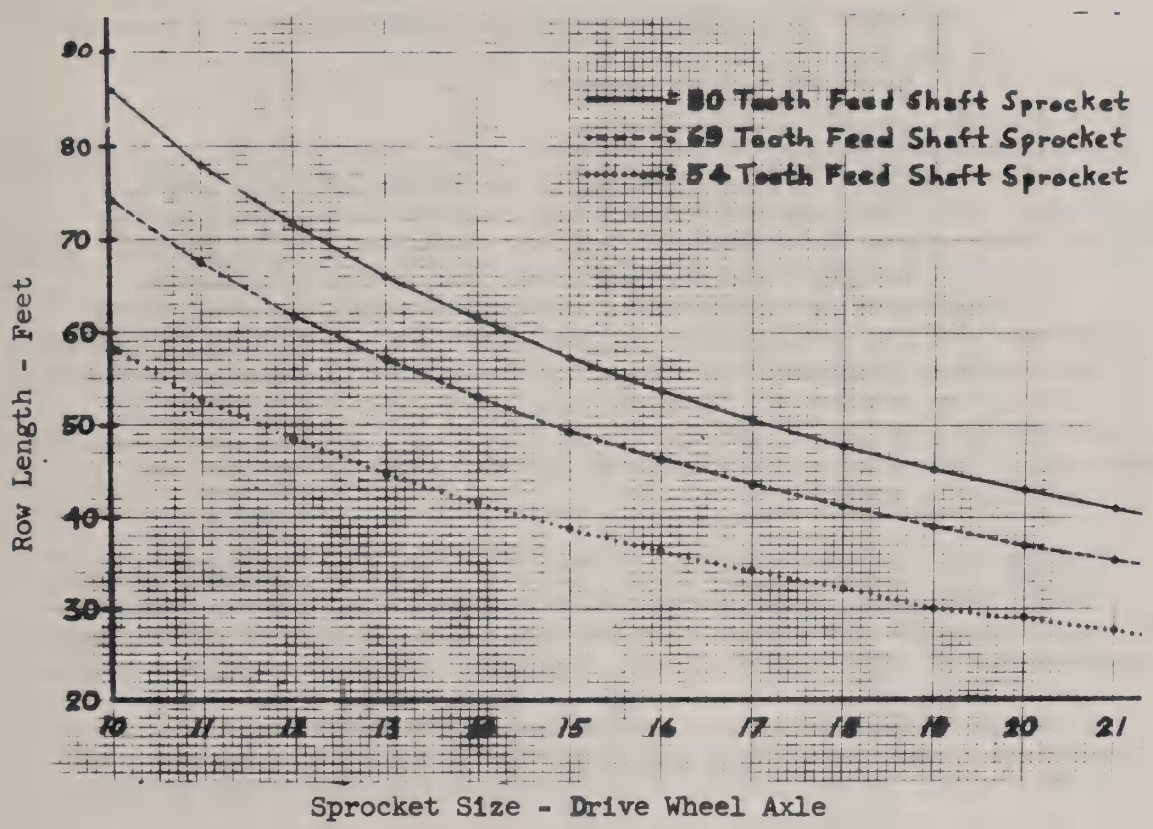


Figure 5. The planter is readily adapted to seeding various plot-row lengths by the selection of drive axle and feed shaft sprocket sizes. Sprocket sizes for drive wheel axle refers to the number of teeth per sprocket.

PROGRESS IN BREEDING FOR YELLOWS RESISTANCE

R. T. Lewellen, J. S. McFarlane, and I. O. Skoyen

In 1968 sugarbeet trials were conducted at Salinas and Davis,[1/] California, for selecting and evaluating self-sterile, inbred (self-fertile), and hybrid materials for yellows resistance. The primary yield trials at Salinas included lines that had been selected for yellows resistance or had components selected for yellows resistance. Because the breeding program for yellows resistance cannot be separated from the breeding programs for curly top resistance, bolting resistance, yield, etc., the results of these Salinas tests will be included in two sections of this report (Development of Breeding Lines and Varieties for California); one section written by J. S. McFarlane et al and one by R. T. Lewellen et al.

In addition to these Salinas tests, inoculated and noninoculated comparisons were made between self-fertile lines and certain European accessions selected for yellows resistance. The results of these tests are presented in later parts of this section.

Continued field selections for yellows resistance were made at Salinas in yellows inoculated, space-planted blocks. Selections were made on the basis of freedom from top symptoms (yellowing and stunting), root size, and sucrose percentage within 13 self-fertile and 5 self-sterile lines. Seed will be obtained from these selected roots in mid-1969.

EVALUATION OF YELLOWS RESISTANCE AT SALINAS

The yield evaluation trials at Salinas in 1968 were divided in two series. One series was inoculated April 25 and 26 with a combination of BYV-7 and BWYV-112, and one series was left as a noninoculated comparison. Each series was composed of several tests.

Table 1 gives the effects of yellows infection on 3-way hybrids and self-sterile varieties. The performance data from which this table was constructed are found in tabular form on pages 16-19 of this report. This table gives the yield reductions and impurity component changes attributed to yellows infection. The varieties tested showed beet yield reductions from 3.0% to 34.0% and gross sucrose reductions from 8.8% to 42.2%. The sucrose concentration losses varied from 0.5 to 2.3 percentage points.

[1/] The assistance of Dr. F. J. Hills of the University of California in arranging for the Davis tests is gratefully acknowledged.

Table 1

Effect of BYV-BWYV infection on yield, sucrose percentage, and impurity components of sugarbeet varieties at Salinas, California, in 1968.

Variety	Description	Reduction in yield and sucrose			Increase in impurity components			
		Sugar Beets		Sucrose	N	Na	K	Imp.
		Percent		Pct.pts.	ppm	ppm	ppm	Index
Y603	YRS 534	8.8	3.0	1.1	-7	38	-281	7
613H4	(562HO x 569) x 613	13.7	7.4	1.1	246	74	-162	205
713B	8th YRS US 75	14.0	6.3	1.3	-121	34	-371	-56
744	YRS (330 x 234)	14.0	10.6	0.6	-26	-5	-254	-25
Y704	YRS 534 x YRS 413	14.2	10.3	0.7	-15	3	-192	-5
713H4	(562HO x 569) x 713 (mm)	14.6	6.6	1.4	376	83	33	330
713TH34	760HO x 413T	14.7	7.9	1.2	73	96	-59	114
734H1	(562HO x 569 + 546) x 534	14.7	10.8	0.7	159	69	-90	131
713H30	(760H4 x 705) x 713 (mm)	15.0	9.6	1.1	106	25	-76	105
534	Rietberg YRS	16.0	13.0	0.6	70	36	-172	47
713A	8th YR, 2nd suc. sel. US 75	16.0	13.4	0.5	157	25	-134	100
713TH32	(754H4 x 716) x 413T	16.8	12.3	0.8	182	77	52	174
713H29	754HO x 713	16.9	12.4	0.9	-116	27	-336	-71
713H38	(760H4 x 702) x 713 (mm)	17.3	12.0	1.0	26	30	-306	26
U713H4	US H9A	18.5	9.5	1.7	388	98	4	344
713H39	(715H3 x 707) x 713 (mm)	18.7	14.5	0.8	20	28	-303	10
730TH33	716HO x 330T	18.8	12.8	1.1	259	135	-65	254
F66-13H11	(563HO x 550) x 413	18.8	13.8	0.9	146	78	-30	148
744H8	(562HO x 546) x 544	18.9	13.5	1.0	67	29	-158	72
713H35	(764H3 x 754) x 713	19.1	13.1	1.1	76	36	-138	98
U713H8	US H9B	19.1	13.1	1.1	184	86	-49	180
713	7th YR, 1st suc. sel. US 75	19.9	17.2	0.6	46	19	-224	24
713H36	(562HO x 707) x 713	20.8	16.2	0.9	-74	52	-284	-33
744H4	(562HO x 569) x 544	21.3	17.8	0.7	87	13	-316	43
613H24	(563HO x 760) x 613	22.0	14.6	1.4	64	51	-180	97
713H37	(562HO x 702) x 713	22.2	13.6	1.7	90	58	-121	144
737	YRS 663	23.1	17.8	1.0	-50	13	-305	-20
730TH32	(754H4 x 716) x 330T	24.6	18.1	1.3	354	152	-216	316
664H4	US H7	25.4	18.3	1.5	296	87	-107	261
730TH35	(764H3 x 754) x 330T	26.6	19.8	1.4	130	46	-231	147
Vanguard	Russell YRS	32.1	20.6	2.3	103	143	-415	230
F66-64	BRS 663	34.6	27.5	1.7	48	39	-423	68
F57-68	US 75	42.2	34.0	2.1	269	112	-305	284

Note: The above data were obtained by comparing varietal performances from adjoining tests that were planted and harvested at the same time. One series of tests was inoculated with BYV-BWYV and a second series was sprayed with Meta-systox. Infection occurred late in the sprayed tests and is not thought to have caused much yield loss. Even though the above data can not be treated statistically, we feel they give a good indication of varietal reaction to yellows infection under conditions of the Salinas tests.

Table 2

VARIETY TEST, SALINAS, CALIFORNIA, 1968

(10 replications of each variety)
(Single-row plots)

Planted: January 4, 1968
Harvested: September 11-12, 1968

Variety	Description	Acre Yield		Sucrose	Bolting	Harvest Count
		Sugar Pounds	Beets Tons	Percent	Percent	Number
7734H32	(754H4 x 716) x 734	14,100	44.67	15.8	1.6	134
7734H33A	716HOM- x 734	14,080	44.83	15.7	3.4	135
7760H33mm	716HOmm x 760	13,950	43.66	16.0	1.4	138
7760H29	754HO x 760	13,910	43.94	15.8	1.5	133
7760H33A	716HOM- x 760	13,710	42.35	16.2	1.3	133
7734H30	(760H4 x 705) x 734	13,600	43.35	15.7	5.0	134
7734H14	534H4 x 734	13,470	41.95	16.1	4.6	134
7757H32	(754H4 x 716) x 757	13,430	43.02	15.7	0.3	138
7716H29	754HO x 716	13,210	42.84	15.4	0.0	142
7716HO	716H3 x 716) x 716	12,810	41.37	15.5	0.0	138
7760HO	(760H4 x 760) x 760	12,670	39.53	16.1	4.8	132
7718H31	(564H3 x 705) x 718 (mm)	12,600	38.83	16.2	0.7	142
7718H32	(754H4 x 716) x 718	12,430	40.34	15.4	0.1	141
7751H32	(754H4 x 716) x 751	12,340	39.31	15.7	0.3	138
7751H31	(764H3 x 705) x 751 (mm)	12,090	35.92	16.8	0.7	143
7753HO	(754H4 x 754) x 753	11,400	37.14	15.4	0.7	133
7705H30	(760H4 x 705) x 705 (mm)	11,060	33.82	16.4	1.4	140
7714H30	(760H4 x 705) x 714 (mm)	11,050	33.25	16.7	1.2	142
7754HO	(754H4 x 754) x 754	10,820	34.82	15.6	0.7	138
7714H31	(764H3 x 705) x 714 (mm)	10,790	32.45	16.7	1.5	140
7705H31	(764H3 x 705) x 705 (mm)	10,550	31.60	16.7	1.2	139
F66-569H3	562HO x 569 (mm)	9,960	30.50	16.3	0.6	138
General MEAN of all varieties		12,450	39.07	16.0		Beets per 100' row
Significant Difference (19:1)		771	2.44	0.51		
Coefficient of Variation (%)		7.03	7.09	3.62		
Calculated F value		22.24**	27.93**	6.10**		

** Exceeds the 1% point of significance (F=1.97)

Table 3

VARIETY TEST, SALINAS, CALIFORNIA, 1968
Inoculated with yellows

(10 replications of each variety)
(Single-row plots)

Planted: January 5, 1968
Harvested: September 16-17, 1968

Variety	Description	Acre Yield Sugar Pounds	Acre Yield Beets Tons	Sucrose Percent	Bolting Percent	Yield loss from yellows Percent	Harvest Count Number
7734H30	(760H4 x 705) x 734	11,400	38.61	14.8	2.2	10.9	143
7760H29	754HO x 760	11,360	38.11	14.9	0.3	13.3	139
7760H33mm	716HOmm x 760	11,310	38.28	14.8	0.4	12.3	145
7760H33A	716HOM- x 760	11,110	37.03	15.0	0.3	12.6	139
7734H33A	716HOM- x 734	10,940	37.30	14.7	0.0	16.8	136
7734H32	(754H4 x 716) x 734	10,890	38.64	14.1	0.4	13.5	142
7734H14	534H4 x 734	10,790	36.65	14.7	0.6	12.6	145
7757H32	(754H4 x 716) x 757	10,680	36.77	14.5	0.3	14.5	142
7760HO	(760H4 x 760) x 760	10,270	34.74	14.8	0.8	12.1	139
7718H31	(764H3 x 705) x 718 (mm)	9,630	32.37	14.9	0.4	16.6	146
7705H30	(760H4 x 705) x 705 (mm)	9,530	30.27	15.7	0.5	10.5	150
7716H29	754HO x 716	9,240	32.94	14.0	0.0	23.1	144
7718H32	(754H4 x 716) x 718	9,070	32.57	13.9	0.0	19.3	149
7751H31	(764H3 x 705) x 751 (mm)	8,900	29.94	14.9	0.0	16.6	149
7753HO	(754H4 x 754) x 753	8,860	31.34	14.1	0.0	15.6	140
7716HO	716H3 x 716) x 716	8,700	30.69	14.2	0.0	25.8	144
7705H31	(764H3 x 705) x 705 (mm)	8,570	27.52	15.6	0.1	12.9	149
7714H31	(764H3 x 705) x 714 (mm)	8,560	27.58	15.5	0.9	15.0	145
7714H30	(760H4 x 705) x 714 (mm)	8,480	28.24	15.0	0.4	15.1	147
7754HO	(754H4 x 754) x 754	8,190	28.40	14.4	0.0	18.4	145
7751H32	(754H4 x 716) x 751	8,110	28.78	14.1	0.0	26.8	143
F66-569H3	562HO x 569 (mm)	7,260	24.48	14.8	0.1	19.7	144
General MEAN of all varieties		9,630	32.79	14.7			Beets per 100' row
Significant Difference (19:1)		635	1.88	0.39			
Coefficient of Variation (%)		7.49	6.51	3.01			
Calculated F value		30.59**	41.82**	12.83**			

** Exceeds the 1% point of significance (F=1.97)

Yellows infection generally caused a decrease in purity as shown by the impurity index. Most varieties showed concentration increases for amino nitrogen and sodium and decreases for potassium. However, just as there were varietal differences for the performance data, the components of impurity showed differences that suggested specific varietal effects for these elements. There did not appear to be a definite relationship between the yield reduction and the impurity change.

Tables 2 and 3 give the performance data for the noninoculated and inoculated F_1 tests, respectively. Table 3 also gives the yield losses from yellows infection. These F_1 hybrids are crosses between a male-sterile component and a self-fertile (inbred) pollinator that have been selected for yellows resistance. The yields of hybrids using 7734 and 7760 indicate that these multigerm inbreds possess good combining ability. The losses from yellows varied from 10.5% to 26.8%. Statistically, these losses are not comparable, but it appears that there would be little difference in resistance between most lines.

EVALUATION OF YELLOWS RESISTANCE AT DAVIS

Plans and Procedures.--Three evaluation tests and one special test were planted May 17, 1968 at Davis. The three varietal evaluation tests included a test of 14 self-sterile lines, a test of 10 hybrids, and a test of 14 F_1 hybrids. Instead of an inbred test as planted in previous years, an F_1 hybrid test was substituted. These F_1 hybrids had inbred pollinators selected for yellows resistance.

The special test was used to evaluate the virulence of BWYV strains. A single uniform sugarbeet variety, F60-547H1, was divided into six virus treatments. Five BWYV strains and a BYV-BWYV combination were used. This test was handled in the same manner as the varietal tests.

Each test was planted in a randomized-block design with five replications. Each replication was then subdivided into split blocks with inoculated and noninoculated treatments. Subplots were two 30-inch rows 40 feet long. The varietal tests were inoculated July 11 with a combination of a virulent strain (7) of beet yellows virus (BYV) and strain 112 of beet western yellows virus (BWYV) of unknown virulence. The BWYV virulence test was inoculated July 23. The plots were harvested October 21-24. Field weights were taken and two 10-beet samples were randomly selected from each subplot for sugar analysis. Amino nitrogen, sodium, and potassium concentrations were determined for the self-sterile and hybrid tests.

As a measure of resistance, the percent loss for root yield and gross sucrose was determined for each pair of inoculated and noninoculated subplots.

Results and Discussion.--In general, the stands of the varietal tests were good and plant numbers were nearly equal between the inoculated and noninoculated comparisons. The plots were thinned late, however, and some setback of growth probably occurred. The inoculated strips showed definite yellows symptoms by August 1. There appeared to be few escapes. By harvest, however, the difference between the inoculation treatments had largely disappeared. This was caused by greener regrowth in the inoculated strips and by some secondary infection in the noninoculated plots. Beet mosaic infected plants were widespread in the plots by October 21.

The results of the self-sterile test are given in Table 4. Under noninoculated conditions there was little difference in yield between varieties. Only F57-68 and 671 were significantly lower yielding than the mean. This lower yield may be partially attributable to old seed which gave slower emergence and establishment than seed from the other lines. The yield differences in the inoculated treatment were greater, reflecting the differences in resistance to yellows. The root yield losses varied from 10.1% for Y704 to 38.8% for F57-63. The yield reductions due to yellows for this test were less than for comparable lines in previous years. The viruses used, particularly BYV-7, were just as virulent as those used in previous years when measured by greenhouse tests. Under nearly the same yellows conditions, the 1968 Davis and Salinas losses were comparable. It is probable that there were factors involved in this reduced loss other than just the late spread of yellows into the noninoculated plots. However, other than suspected environmental effects, the reasons are unknown.

The losses in terms of gross sucrose were greater than for root yield. Losses varied from 15.3% for 713B to 42.6% for F57-63.

One of the best performing lines was Y704. Y704 is an F_2 from a cross between the parental lines of Y603 and 713. When the performance of this line is compared with 713 and Y603, Y704 shows greater resistance and higher root and gross sucrose yields, but the sucrose percentage is no better than the lower of the two lines. This was true at both Salinas and Davis in 1968. When the same comparison is made for 744, a cross between the parental lines of Y603 and 630, the same responses are evident.

At Davis and Salinas the yellows infection generally caused the amino nitrogen and sodium concentrations to increase. However, the potassium concentrations decreased at Salinas with little change at Davis. The 1967 observation that yellows infection caused greater increases in amino nitrogen and sodium for US 75 than for the lines (e.g., 713B) selected from US 75 was confirmed.

The results of the hybrid test are given in Table 5. US H7 (664H4), which has no component selected for yellows resistance, had significantly lower root and gross sucrose yields for both noninoculated and inoculated treatments than most of the other hybrids with one or more yellows resistant components. Root yield losses varied from 14.0% to 28.4% and gross sucrose losses varied from 18.2% to 35.0% for 713TH32 and 664H4, respectively.

Table 4. Reduction in yield and performance of self-sterile sugarbeet lines under BYV-BWYV inoculated and noninoculated treatments at Davis, California, in 1968.

No.	Description	Tons Roots/A		Yield Loss	Sucrose %		Gross Sucrose		Gross Suc. Loss
		Check	Inoc.	%	Check	Inoc.	Check	Inoc.	%
Y704	YRS 534 x YRS 413	28.7	25.7	10.1	14.8	13.6	8510	6960	18.0
713B	8th YRS US 75	27.1	23.6	12.5	14.1	13.7	7640	6460	15.3
713T	Increase 613T	28.6	24.0	15.6	14.0	13.3	7940	6380	19.8
Y603	YRS 534	26.2	21.8	15.8	15.6	14.6	8150	6380	21.0
744	YRS (330 x 234)	28.8	24.0	16.2	14.7	13.8	8470	6630	21.1
713	7th YR, 1st suc. sel. US 75	27.9	21.9	20.7	14.4	13.9	8000	6100	23.2
630	7th YRS US 75	26.5	20.6	21.5	14.7	14.1	7810	5820	25.0
713A	8th YR, 2nd suc. sel. US 75	27.5	20.0	24.8	15.0	14.5	8280	5810	27.7
730T	330 tetra	28.6	21.2	25.6	14.4	13.5	8220	5710	30.3
F57-68	US 75	22.5	15.8	28.0	14.6	13.2	6570	4170	34.5
737	YRS 663	28.0	19.8	29.3	14.0	13.0	7860	5130	34.5
521	5th YRS 671	28.0	19.6	29.5	14.4	13.0	8020	5080	36.2
671	Type 0 line	19.8	13.7	29.5	15.1	14.1	6000	3850	34.0
F57-63	Increase 663	26.5	16.2	38.8	14.5	13.6	7690	4410	42.6
MEAN		26.8	20.6	22.7	14.6	13.7	7800	5640	27.4
LSD (5%)		3.0	2.5	9.9	0.7	0.6	871	693	10.1
CV		8.8	9.7	34.2	3.9	3.6	8.8	9.7	29.0

Table 4 (continued). Reduction in yield and performance of self-sterile sugarbeet lines under BYV-BWYV inoculated and noninoculated treatments at Davis, California, in 1968.

No.	NH_2-N ppm		Na ppm		K ppm		Impurity Index	
	Check	Inoc.	Check	Inoc.	Check	Inoc.	Check	Inoc.
Y704	543	578	316	464	3605	3894	1049	1267
713B	510	481	328	361	3617	3660	1084	1116
713T	562	552	404	508	3623	3734	1161	1261
Y603	547	587	449	578	3230	3162	972	1083
744	520	508	404	597	3285	3230	1011	1102
713	591	642	338	395	3642	3685	1134	1230
630	606	622	339	435	3451	3385	1080	1161
713A	519	535	256	340	3340	3384	961	1040
730T	816	821	486	672	3340	3199	1279	1386
F57-68	678	925	476	698	3353	3334	1158	1516
737	564	637	509	650	3697	3802	1195	1408
521	706	730	840	1006	3285	3212	1277	1464
671	739	750	634	697	3181	3175	1172	1274
F57-63	591	642	511	637	3568	3463	1150	1275
MEAN	606	643	449	574	3444	3451	1120	1256
LSD (5%)	136	144	153	166	224	251	165	164
CV	17.7	17.7	26.9	22.8	5.1	5.7	11.6	10.3

Table 5. Reduction in yield and performance of sugarbeet hybrids under BYV-BWYV inoculated and noninoculated treatments at Davis, California, in 1968.

No.	Description	Tons Roots/A		Yield Loss	Sucrose %		Gross Sucrose		Gross Suc. Loss
		Check	Inoc.	%	Check	Inoc.	Check	Inoc.	%
713TH32	(754H4 x 716) x 413T	33.2	28.4	14.0	14.7	14.0	9740	7950	18.2
713TH34	760HO x 413T	35.7	28.9	18.7	14.1	13.9	10000	7970	20.0
U713H8	US H9B	32.0	25.4	20.3	14.7	14.1	9380	7160	23.5
730TH32	(754H4 x 716) x 330T	34.2	26.9	20.8	14.3	13.8	9800	7400	23.8
730TH33	716HO x 330T	34.3	26.9	21.6	15.0	14.5	10250	7790	24.1
U713H4	US H9A	29.7	22.8	22.3	15.0	14.4	8850	6570	25.5
734H1	(562HO x 569 + 546) x 534	30.7	23.6	22.6	15.0	14.6	9210	6850	25.2
713H30	(760H4 x 705) x 713 (mm)	31.7	24.1	23.8	15.5	14.9	9750	7200	26.2
713H4	(562HO x 569) x 713 (mm)	32.3	23.7	26.6	15.3	14.7	9850	6920	29.7
664H4	US H7	28.4	20.2	28.4	15.2	13.8	8570	5540	35.0
MEAN		32.2	25.1	21.9	14.9	14.3	9540	7130	25.1
LSD (5%)		2.8	3.2	6.5	NS	NS	703	743	7.0
CV		6.7	10.1	23.2	5.1	4.7	5.7	8.1	21.7

No.	NH_2-N ppm		Na ppm		K ppm		Impurity Index	
	Check	Inoc.	Check	Inoc.	Check	Inoc.	Check	Inoc.
713TH32	606	579	365	504	3322	3390	1067	1148
713TH34	587	536	396	397	3765	3771	1190	1172
U713H8	662	612	392	401	3322	3297	1120	1121
730TH32	765	709	657	674	3679	3697	1348	1379
730TH33	798	719	516	477	3636	3396	1268	1204
U713H4	657	653	340	371	3384	3248	1094	1112
734H1	651	610	562	589	3543	3304	1157	1138
713H30	658	628	424	475	3168	3316	1051	1097
713H4	625	698	294	355	3636	3451	1077	1153
664H4	670	722	489	606	3457	3414	1137	1311
MEAN	668	646	443	485	3491	3428	1151	1183
LSD (5%)	NS	NS	213	NS	266	190	NS	NS
CV	17.0	22.0	37.4	35.7	5.9	4.3	14.3	16.0

Table 6. Reduction in yield and performance of sugarbeet F_1 hybrids under BYV-BWYV inoculated and noninoculated treatments at Davis, California, in 1968.

No.	Description	Tons Roots/A		Yield Loss	Sucrose %		Gross Sucrose		Gross Suc. Loss
		Check	Inoc.	%	Check	Inoc.	Check	Inoc.	%
7760H0	(760H4 x 760) x 760	27.7	22.4	18.5	13.2	13.0	7370	5830	19.7
7760H33A	716H0 M- x 760	32.6	26.4	19.2	13.6	13.0	8900	6860	22.7
7734H30	(760H4 x 705) x 734	33.8	27.2	19.5	13.5	13.2	9100	7120	21.6
7760H29	754H0 x 760	30.4	24.2	20.6	13.2	12.9	8030	6270	22.4
7705H30	(760H4 x 705) x 705 (mm)	24.9	18.5	25.9	14.8	14.2	7370	5250	28.9
F60-547H1	MS of NB1 x NB5	21.2	15.4	27.2	13.8	12.7	5840	3940	32.8
7716H29	754H0 x 716	32.7	23.4	28.4	12.7	11.9	8270	5570	32.7
7757H32	(754H4 x 716) x 757	30.6	21.9	28.6	12.6	12.3	7730	5390	30.1
7705H29	(563H0 x 754) x 705	28.0	19.6	30.4	13.8	13.4	7780	5280	32.6
7716H0	(716H3 x 716) x 716	30.2	21.1	30.2	12.4	11.3	7490	4800	36.1
7718H32	(754H4 x 716) x 718	30.8	21.0	31.8	12.8	11.9	7850	5000	36.5
7751H32	(754H4 x 716) x 751	28.8	19.4	33.0	13.2	12.4	7600	4830	36.7
7754H0	(754H4 x 754) x 754	25.1	16.6	33.6	13.0	12.6	6500	4170	35.7
7714H30	(760H4 x 705) x 714 (mm)	25.2	16.8	33.9	14.7	13.9	7420	4680	37.4
MEAN		28.7	21.0	27.2	13.4	12.8	7660	5360	30.4
LSD (5%)		2.7	2.4	7.9	0.6	0.6	756	638	8.6
CV		7.4	8.9	22.8	3.6	3.5	7.8	9.4	22.1

Unlike the open-pollinated lines, these hybrids showed no general upward trend for amino nitrogen and sodium concentrations when infected with yellows at Davis. In the Salinas tests, however, there was a general increase for these constituents and a decrease in potassium concentration.

The results of the F_1 hybrid test are shown in Table 6. Root yield losses varied from 18.5% to 33.9% and gross sucrose losses from 19.7% to 37.4%. The multigerm inbred 7734 showed good combining ability in the 7734H30 hybrid. The multigerm inbred 7760 and its male sterile form had the greatest resistance to yellows and was a component in the most resistant hybrids.

The results of the special test to determine the most virulent BWYV strain were inconclusive. There were no significant differences among the strains. F60-547H1, the host hybrid variety, was reduced only 10% in this test by the BYV-BWYV inoculation. A similar test will be tried in 1969 using a different host variety with additional strains of BWYV. The isolation of a virulent strain for use in the yellows breeding program is important.

DEVELOPMENT OF YELLOWS RESISTANT INBREDS

The program for developing inbreds with yellows resistance was continued in 1968. Nine early generation inbred lines were grown in a space planted selection block at Salinas. Each plant was inoculated with BYV and BWYV and selected on the basis of freedom from yellowing, root weight, and sucrose percentage. Emphasis was placed on selecting in monogerm lines or lines segregating for monogerm seed. Several monogerm lines previously selected were indexed for type O and CMS equivalents were initiated.

The relative resistance of inbred lines to yellows has been determined at Davis using inoculated and noninoculated subplots in a split-block design. However, due to the late start to avoid aphid flights and the hot temperatures in combination with low vigor, the inbreds have done poorly. The number of lines that can be tested in a year is also limited. In consideration of these factors, an inbred test was not grown at Davis in 1968. Alternatively, the inbreds were planted at Salinas.

The 32 inbreds listed in Table 1 were tested. Of these 13 were monogerm and 19 were multigerm. One monogerm line, F66-562, and three multigerm lines, 0539, F56-502HO, and F56-511, were included as standard or susceptible inbreds not selected for yellows resistance. Three of the multigerm lines were near CMS equivalents with three backcrosses. Four multigerm, tetraploid inbreds were also included. The yellows resistant inbreds had been selfed for two to eight times and most were S_3s or S_4s.

Duplicate tests were planted March 11. Plots were 31 ft. long on 28 inch centers. On May 6 when the plants were in the six-to-ten leaf stage, one of the tests was inoculated with a combination of BYV-7 and BWYV-112. Comparisons between inoculated and noninoculated plots were made for symptom expression and general appearance throughout the growing season. The tests were harvested September 4 and root yields and sucrose percentages determined.

Natural spread of yellows normally occurs with little difference between inoculated and noninoculated tests except in the uniformity of infection. This year, however, little spread of yellows occurred early and the two virus treatments remained important throughout the season. Because the tests were planned primarily as observational tests, only two replications under each virus treatment were planted.

The results of the inbred trials are given in Table 1. The inbreds are ranked in the order of their % yield loss. Of the entries in the most resistant half, only three are monogerm lines, 7724, 7705A, and 6707. In the more susceptible half, all are monogerm except 7748, 7716T, 7753T, 0539, F56-502HO, and F56-511. From this difference it can be seen that work is needed to increase resistance in monogerm lines.

On the basis of % yield loss and what is known from previous inbred test results, these lines appear to fall into the correct perspective. For example, among the multigerm lines, 760, 757, and 704 have been the most resistant, 753, 754, and 716 have been intermediate, and 539, 502HO, and 511 have been susceptible in Davis tests.

The most significant outcome of this test is the apparent resistance of monogerm 7724. It not only gave the least yield reduction but was also outstanding through the season in the inoculated plots for its greenness and lack of chlorotic and necrotic foliar symptoms. 7724 is an S_2 line and was also included as one of the inbreds to be selected for yellows resistance in the space planted selection plot.

Line 7705A was second among the monogerm inbreds. In previous tests it has appeared to be the most resistant monogerm line and has had a good sucrose percentage. In 1967 a type O selection was made in this line and seed from the type O plants was bulked and included in the 1968 yellows resistant selection plot. 705HO equivalents have been started and 705 has been used as a parent in several hybrid crosses.

Since monogerm inbreds are needed for the production of monogerm hybrids, the usefulness of the yellows resistant, multigerm inbreds is limited. However, they are being used in experimental hybrid combinations to study the transmission of their yellows resistance into hybrid combinations. They are also useful as parents in crosses with monogerm lines to obtain yellows resistant, monogerm inbreds. They were used for this purpose in the 1968 crossing program.

The third backcross CMS equivalents of 754, 760, and 716 were tested. In terms of top and root growth, these lines appeared to have some hybrid vigor.

The four tetraploid inbreds yielded less and were more susceptible than their diploid parental lines.

The sucrose percentage of the inbred lines was not outstanding. Under noninoculated conditions, 10 of the 32 lines had greater than 15% sucrose. Sucrose loss varied from 0 to 2.4 percentage points and the average loss was 1.1 points.

Plant vigor is suspected of influencing the expression of resistance to yellows in terms of the % yield loss between infected and noninfected comparisons. For example, a hybrid between two susceptible inbreds normally shows less yield loss than either of the inbreds tested individually. There is some question then as to the relative importance of vigor and genetic resistance in the expression of % yield loss for these inbreds. To obtain evidence as to the importance of vigor, a correlation was determined between the % yield loss and the yields of the noninoculated lines. A nonsignificant correlation coefficient ($r = -.38$) was obtained. Therefore, the lines vary essentially independently with

Table 1. Reduction in yield and performance of inbred lines under BYV-BWYV inoculated and noninoculated treatments at Salinas, California, 1968

No.	Description	Tons Roots/Acre			% Sucrose	
		Check	Inoc.	% Loss	Check	Inoc.
7724	YRS (321 x 764)	14.98	11.67	22.6	14.4	13.4
5760	YRS (911_3 x 717)	18.90	13.33	25.2	15.5	14.7
7754HO	HO x 754^3	22.28	16.49	26.3	14.9	13.5
7703	YRS (121 x 539)	17.50	12.35	28.3	13.9	12.1
7757	YRS (911_3 x 716)	26.95	18.29	31.0	13.4	13.1
7760HO	HO x 760^3	27.40	18.82	31.2	15.6	13.8
7704	YRS (121 x 716)	22.28	15.06	32.7	14.3	13.4
7734	Inc. (927 x 5577)	23.11	14.91	34.3	14.5	14.1
7704T	Inc. C_1 4704	15.81	10.09	34.7	13.2	12.3
7705A	YRS (121_1 x 743)	18.07	11.07	35.9	15.7	14.9
7753	YRS (671_3 x 716)	16.26	10.47	36.7	13.3	12.5
7716HO	HO x 716^3	27.18	15.69	41.2	14.2	13.7
7757T	Inc. C_1 3757	17.54	10.19	42.5	14.3	13.9
6707	Inc. (121_1 x 550)	13.02	7.23	44.3	15.4	15.0
7754	YRS (671 x 716)	17.62	9.99	44.9	12.8	13.3
7716	YRS 7628-24	18.82	9.99	45.7	14.6	12.5
7748	Inc. Acc. 106	11.29	5.72	46.6	15.9	14.4
7716T	Inc. C_1 3716	16.41	8.51	47.2	13.8	12.7
5764	YRS 583, 711, 763, 764	17.01	8.66	49.1	15.2	14.5
7753T	Inc. C_1 3753	8.36	3.99	52.3	12.6	12.6
F66-562	mm	14.60	6.25	57.2	15.4	13.9
7718	Inc. (563 x 716)	12.04	4.52	58.4	14.9	12.7
7722	YRS (330 x 563)	16.57	7.00	58.5	14.3	12.3
6714	Inc. (563 x 743)	13.32	4.90	63.4	15.5	13.8
0539	NB7	22.36	8.05	64.3	11.6	11.4
7701	YRS (121 x 1711)	14.68	5.20	64.9	14.7	13.0
7735	Inc. (541 x 714)	12.05	3.62	69.9	13.7	14.1
7702	YRS (121 x 563)	12.35	3.54	70.6	15.8	13.4
5715	YRS (mmaa x 561)	17.02	4.67	71.1	15.7	14.5
7751	Inc. (563 x 716)	18.74	4.82	73.8	14.5	12.3
F56-502HO	NB1HO	17.54	4.44	76.0	13.9	11.5
F56-511	NB2	14.90	3.39	77.7	15.0	13.0
	LSD (.05)	5.51	4.31		1.3	1.6

respect to yellows resistance and yield under noninfected conditions and their yield performance cannot be used to predict their response to yellows infection. The third backcross HO equivalents and the tetraploids were not included in this or the following determination.

Because of the limitations and inconveniences of testing inbred lines at Davis, and because at Salinas natural infection usually prevents noninfected checks, a method of selecting between large numbers of inbred lines under inoculated conditions at Salinas would be desirable. Since the noninoculated test remained healthy in 1968, the relationship between resistance and yield performance of infected inbreds could be determined. A highly significant correlation coefficient ($r = -.88$) was obtained between the % yield loss and the root yield under inoculated conditions. Therefore, as the inbred lines increased in resistance to yellows, their yield also increased. The yellows resistance of inbred lines can then be more or less determined by their rank in yield under severe yellows infection. This would permit the best lines to be selected at Salinas in a year when only diseased conditions were possible.

The selection of the highest yielding inbreds at Salinas would allow rapid and inexpensive elimination of the poorer inbreds without fear of discarding the most resistant ones. The inbreds that were selected at Salinas could then be tested in controlled inoculation trials at Davis. On the basis of the Davis tests, the most resistant lines could be evaluated for combining ability.

Testing for resistance at Salinas under infected conditions may work as long as there is a wide range in resistance among the lines. Actually, the correlation between resistance and yield under inoculated conditions has been assumed in our selection technique for individual beets within a line. By selecting the largest roots in a population, we have assumed that the most favorable resistance gene combinations have also been selected and were at least partially responsible for the larger roots.

Inbred tests will be planted at Salinas and Davis in 1969 to further evaluate resistance and the possibility of utilizing infected inbred yields as partial measurements of resistance.

YELLOWS RESISTANCE OF EUROPEAN SELECTIONS

During 1967 beet seed samples which had been selected for virus yellows resistance (tolerance) were received from Dr. Hendriksen of the D. J. Van der Have Station in The Netherlands and Dr. Henk Rietberg of Instituut voor Rationele Suikerproductie in The Netherlands. These sugarbeet lines were grown at Salinas, California, in 1968 and evaluated for resistance to virus yellows.

Nine lines were received from Dr. Hendriksen representing sugarbeets from diverse sources. All were open-pollinated, diploid, multigerm lines.

There were 39 lines from Dr. Rietberg. These lines were inbred, hybrid, and open-pollinated selections.

Trials composed of Dr. Hendriksen's lines, two of Dr. Rietberg's lines, and three U.S.D.A. varieties were planted March 11. The 14 selections were planted in duplicate tests with four replications each. One of these tests was inoculated May 6 with a highly virulent strain of beet yellows virus (BYV-7) and strain 112 of beet western yellows virus (BWYV). The adjacent test was left as a noninoculated check. Plots were 31 ft. long on 28 inch centers. These tests were harvested September 5 and root weights and sucrose percentages were determined.

The U.S.D.A. lines used as checks were US 75, 713A, and Y603. US 75 is a moderately susceptible variety. 713A is a moderately resistant selection from US 75. Y603 is a selection made at Salinas from a yellows tolerant line furnished by Dr. Henk Rietberg.

The remaining 37 lines of Rietberg's material were planted in one of two tests, depending upon the available seed. Because most of Dr. Rietberg's selections had very low field emergence and stands were erratic, data for these selections are not included in this report.

The two Rietberg lines included in the first test also had poor stands and they are deleted from the test results. The plots adjacent to these selections were adjusted for yield with a consideration of the number of missing feet of row and how the same line yielded in other replications with normal competition.

There was little spread of yellows into the noninoculated plots until late in the season, whereas, a high percentage of inoculated plants showed symptoms soon after being inoculated.

The results for root yield, sucrose percentage, and % yield loss are presented in Table 1. In general, Y603, 713A, and the Van der Have material were similar for root yield. US 75, Va l.c.i., and Vf 37 gave lower yields. The sucrose percentage was similar for most lines with 713A, Y603, Vb 51, Vh 6, and Vs 23 being slightly higher.

Table 1. Reduction in yield and performance of European yellows resistant selections under BYV-BWYV inoculated and noninoculated treatments at Salinas, California, in 1968

Seed Lot No.	Symbol	Tons Roots/Acre			% Sucrose	
		Check	Inoc.	% Loss	Check	Inoc.
F57-68		20.10	7.90	60.4	15.0	14.1
713A		22.73	16.86	23.4	15.4	15.4
Y603		27.18	20.29	25.5	15.3	15.7
1434-66	Va l.c.i.	18.67	11.03	40.4	14.8	14.1
6007-63	Vb 51	20.36	10.69	47.8	15.6	15.3
12438-61	Vc 5	27.33	13.70	49.9	13.2	13.8
1462-66	Vd 102	26.72	17.50	34.7	13.4	13.4
1464-66	Ve 14	22.58	15.92	29.4	14.1	13.6
6010-63	Vf 37	19.38	11.82	37.4	14.7	14.5
1468-66	Vh 6	22.09	12.27	44.1	15.3	14.4
26253-64	Vs 23	24.28	13.33	45.0	16.3	14.6
1470-66	VT p.c.	25.63	17.99	29.0	14.6	14.4
	LSD (.05)	3.41	2.70		0.76	0.87

The yield of individual lines was more variable when infected with yellows. Y603 yielded significantly more than any other line. The inoculated lines generally had lower sucrose percentages than the non-inoculated check, although differences were small. When compared visually, Vd 102 and Ve 14 were greenest and compared closely to 713A and Y603 for top symptoms.

Our potential use of the Van der Have material would be as a source of additional yellows resistance genes. Because these lines possess no curly top resistance and little bolting resistance, they are of limited use otherwise in California. The most important data from this test then are the % yield losses which gives the lines comparative resistance to yellows.

As shown in Table 1, the most resistant lines were 713A and Y603. The most susceptible was US 75. The Van der Have lines varied from nearly as resistant to nearly as susceptible. VT p.c. with a 29% loss was the most resistant foreign line. According to Dr. Hendriksen, VT p.c. is a polycross of numerous tolerant selections from various relationship groups. Line Ve 14 also showed 29% loss. Two other lines, Vd 102 and Vf 37, showed less than 40% loss.

Because VT p.c. appeared to have the best resistance, it will be tested further in our yellows resistance program. This line also should have a wide genetic background with many of the yellows resistance genes accumulated in Europe. Additional work may be done on several of the other better lines either as they are or in a bulk population. It is likely, however, that our Y603 already possess most of the factors of the Van der Have lines for yellows resistance in a much more suitable background.

BEET YELLOWS DISEASE: CORRELATION BETWEEN AMINO ACID RATIO AND TOLERANCE OF TWO SUGAR BEET SELECTIONS MADE BY DIFFERENT SELECTION SCHEMES

by

J. M. Fife

Two yellows-tolerant sugar beet selections (413 and RS-3), made by two different selection schemes, were tested to show the similarity in field performance and in their amino acid ratios relative to that of their common parent, variety US 75.

Selection 413 (developed by McFarlane and Bennett) was made by mass selection from field-inoculated plants on the basis of top symptoms and root size and carried through the 5th selection cycle. The resistance of this selection to beet yellows, relative to its parent, has been reported.

Selection RS-3, an outstanding sib of the second selection cycle, was made by mass selection on the basis of the magnitude of the amino acid ratio (concentration: $\frac{\text{aspartic acid + glutamic acid}}{\text{glutamine}}$), in newly-matured leaves of inoculated greenhouse-grown plants with chronic symptoms of the disease, and root weight. The degree of tolerance, obtained by this selection scheme, is shown by 4 years of testing this selection and its parent using a latin square design (Fig. 1). The planting dates were between April 8 and April 30. The growing season ranged from 162 to 180 days. By thinning time, practically all plants had become infected with beet yellowing viruses. In addition to the natural infection, each plant was inoculated with a virulent isolate of beet yellows virus (BYV) soon after thinning.

The percentage sucrose and the yield of sugar per acre was significantly greater in the selection ($P = 0.01$) than the parent for all 4 years. In 1963 and 1964, the plants were inoculated with BYV strain 5. In these 2 tests, the yield of beets of the selection was greater than the parent, but not significantly so. The 1963 test was inoculated late in the season, after 47% of the growing period was over. The late inoculation would account, not only for the relatively high yield of roots for that year, but also for the small difference in root yield between the selection and the parent. The 1965 and 1966 tests were inoculated early, 5 weeks after emergence, with a strain more virulent (Brawley) than strain 5. In these 2 tests the beet yield of the selection was significantly greater ($P = 0.05$) than the parent. This suggests that this selection, and other sibs of the second selection cycle, may show even greater relative tolerance to the most virulent strains of BYV than that shown by the parent variety.

Yellows-tolerant selection 413 was included in the 1966 field test (8 x 8 latin square design) to compare its performance with selection RS-3 and their common parent. Plants of these selections and the parent were also grown in the greenhouse to determine their amino acid ratios in newly-matured leaves with chronic symptoms of the disease. Plants in both field and greenhouse tests were inoculated with the same virulent strain of BYV.

The percentage sucrose, yield of beets, sugar per acre and the amino acid ratios of both selections were similar and significantly greater than their parent (Table 1). At harvest, both selections were darker green and had fewer dead leaves than the parent.

Discussion and Summary

It would appear that considerable significance may be attached to the fact that two wholly different schemes of selection for resistance to virus yellows in sugar beets gave complimentary results. Selection, largely on the basis of a high amino acid ratio in leaves, gave a significant increase in resistance as indicated by both sucrose content and root weight. Conversely, field selection on the basis of top symptoms and root size produced a selection that has a high amino acid ratio. These data are further evidence that the amino acid ratio in newly-matured leaves of infected plants is correlated with resistance to beet yellows, especially as related to reducing losses in percent sucrose.

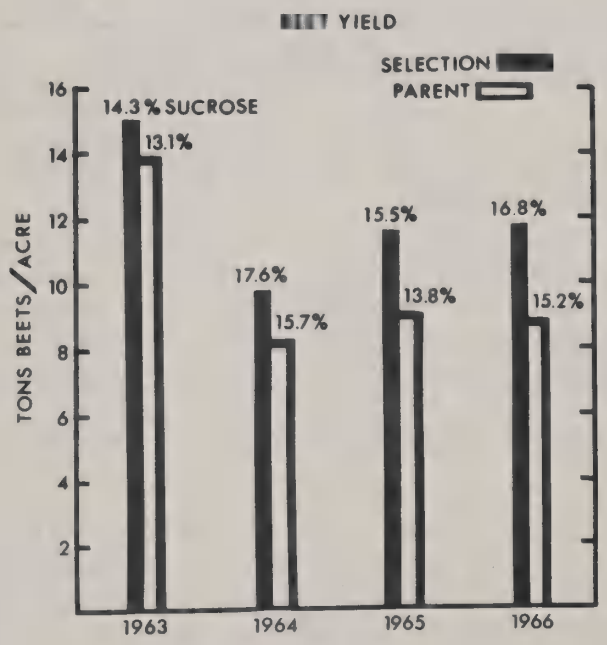


Figure 1. Performance of sugar beet selection RS-3, made in the greenhouse on the basis of the magnitude of the amino acid ratio and root weight from plant populations infected with a virulent strain of BYV.

Table 1.

Performance of two beet yellows-tolerant selections, each made by a different selection scheme but originating from the same parent.

Selection	Sucrose	Acre Yield		Amino Acid Ratio 1/
		Beets	Sugar	
	%	Tons	Pounds	
US 75 (Parent)	15.2	8.9	2,726	.21
413 (5th Sel. cycle)	16.5**	14.4**	4,740**	.39**
RS-3 (2nd Sel. cycle)	16.8**	11.8*	3,978**	.45**

1/ Amino Acid Ratio: concentration of, $\frac{\text{Aspartic + Glutamic}}{\text{Glutamine}}$

**, * Significantly greater than the parent at the 1% and 5% levels respectively.

VIRUS INVESTIGATIONS

J. E. Duffus

Yellowing Viruses: Five yellowing viruses have been described from the complex of beet yellowing diseases called yellows in the U.S.A.: (a) semi-persistent aphid-transmitted viruses with rather restricted natural weed host ranges and localized distribution (beet yellows virus, beet yellow stunt virus); (b) persistent aphid-transmitted virus with extremely wide natural weed host ranges and widespread distribution (beet western yellows virus, malva yellows virus); and (c) a whitefly-transmitted virus (beet pseudo-yellows virus).

Currently, two of these viruses, beet yellows virus and beet western yellows virus, are causing major economic damage to sugarbeet. The other viruses seem to be of relatively greater importance on other crops--lettuce, spinach and the crucifers. (See Abstract Duffus, 1968).

Beet western yellows virus has a much wider distribution throughout the U.S.A. than the beet yellows virus. This virus is widely distributed throughout the Western States and is easily found in Eastern beet growing areas. It is a circulative aphid-transmitted virus and occurs in a number of strains differing in host range (Duffus, 1964).

Beet western yellows virus is similar in host reaction and aphid transmission to a number of other aphid-transmitted viruses, including potato leafroll virus, barley yellow dwarf virus, beet mild yellowing virus, turnip latent virus, Physalis mild chlorosis virus, turnip yellows virus, etc. Undoubtedly some of the reported yellows type viruses are related. The application of the membrane feeding technique (Duffus and Gold, 1965) to *in vitro* property tests and infectivity neutralization tests (Gold and Duffus, 1967) may clarify the relationships.

One of the most striking similarities in symptomology between viruses of the western yellows type occurs with beet western yellows virus and potato leafroll virus. Both entities cause similar reactions in some solanaceous hosts, *Physalis floridana* Rydb., *Datura stramonium* L., *Nicotiana clevelandii* Gray, and *Petunia hybrida* Vilm.

Beet western yellows virus is transmitted to over 96 plant species in 21 plant families.

Potato leafroll virus has a rather restricted host range, attacking mainly solanaceous hosts. The virus has been reported, however, to infect species in the Cruciferae, Amaranthaceae and Chenopodiaceae. These host range and symptomology similarities prompted an attempt to study the serological relationship of these two similar circulative viruses. (See Abstract Duffus, 1969).

Currently tests of this nature are underway with other yellowing isolates in an effort to determine the relationship or lack of relationship to beet western yellows virus.

Occurrence of Western Yellows in Southwestern Idaho: Apparently the incidence of beet yellowing viruses or the concern about this type of yellowing has increased in Southwestern Idaho in recent years.

During the fall of 1967, Dr. Donald L. Oldemeyer (The Amalgamated Sugar Company) sent 136 individual leaf samples from plants suspected of having yellows in 40 different locations in Southwestern Idaho, for identification of yellowing viruses. Identification of the viruses from the leaves was based on visual symptoms and in a number of instances, attempted recovery of viruses to sensitive indicator hosts by nonviruliferous green peach aphids.

The results of these tests (Table 1) indicate a widespread distribution of beet western yellows virus in Southwestern Idaho. No evidence of the occurrence of the beet yellows virus was obtained.

Although only 33 of the samples were indexed by recovery to sensitive indicator hosts, the high accuracy of the visual method (29 out of 33 observations correct) would indicate the observations are essentially correct.

Curly Top: Qualitative aspects of curly top transmission as measured by radio active isotopes - An obvious need in the study of virus-vector relationships is the development of new quantitative methods which relate the number of virus particles taken in by an animal vector with its subsequent infectivity. The use of radio active tracers in measuring feeding volumes (Duffus and Gold, 1967) led to a study of quantitative aspects of curly top transmission. Factors studied which affect the sensitivity of feeding transmission measurements include radiation effects, excretation rates, geometry and tropisms, temperature, illumination, pH, sex and age of insects.

In most experiments a 10-20 fold variation between individuals in volume of uptake was noted. The application of this fact to other studies of virus-vector relationships is obvious. Volume of uptake is one variable of transmission but there are obviously others. The application of these techniques to genetic studies of vector transmission could be significant. Significant correlation between uptake and transmission efficiency at short feeding intervals has been noted.

Table 1. Occurrence of beet yellowing viruses in Southwestern Idaho - 1967

Area	Plant 1		Plant 2		Plant 3	
	Visual	Indexing	Visual	Indexing	Visual	Indexing
1	WY	0	WY	--	WY	--
2	WY	WY	WY	--	WY	--
3	WY	0	WY	--	WY	--
4	WY	WY	WY	--	WY	--
5	WY	WY	WY	--	WY	--
6	WY	--	WY	--	WY	--
7	0	--	0	0	0	0
8	0	--	0	0	0	0
9	WY	--	WY	--	WY	--
10	WY	WY	WY	--	WY	--
11	WY	WY	--	--	--	--
12	WY	--	WY	--	--	--
13	WY	--	WY	--	--	--
14	WY	WY	WY	--	WY	--
15	0	0	WY	--	WY	--
16	WY	--	WY	--	WY	--
17	WY	WY	WY	--	WY	--
18	WY	--	WY	--	WY	--
19	WY	--	0	--	WY	--
20	WY	WY	WY	--	WY	--
21	WY	WY	WY	--	WY	--
22	WY	--	WY	--	WY	--
23	WY	0	WY	--	WY	--
24	0	0	0	--	0	--
25	WY	--	WY	--	WY	--
26	WY	--	WY	WY	WY	WY
27	WY	--	WY	--	WY	--
28	WY	--	WY	WY	WY	WY
29	WY	--	WY	--	WY	--
30	WY	WY	WY	--	WY	--
31	WY	WY	WY	--	WY	--
32	WY	--	WY	--	WY	--
33	WY	WY	WY	WY	WY	--
34	WY	--	WY	--	0	0
35	WY	--	WY	--	WY	--
36	WY	WY	WY	WY	WY	--
37	WY	WY	WY	--	WY	--
38	WY	--	WY	--	WY	WY
39	WY	--	WY	--	0	0
40	WY	--	WY	--	0	WY

WY - Western yellows
0 - Not virus induced yellowing
-- - Not checked

Breeding Sugarbeet for Resistance to the Sugarbeet Nematode Heterodera schachtii Schm.

Devon L. Doney and E. D. Whitney

A. Selection

Nematode resistance in sugarbeet would be of great economic importance to the sugarbeet industry. Much effort in the past has achieved only moderate success. Two difficulties have been encountered in the past that have greatly hampered the achievement of this goal.

The first difficulty comes from the fact that resistance has only been found in the Patellares section of the Beta genus. It has been extremely difficult to cross and incorporate any genetic material from the Patellares section into the Vulgares section.

The second difficulty has been the large environmental errors encountered with nematode damage. This has made it difficult to select small true differences in tolerance or resistance within the cultivated sugarbeet.

Several selection schemes have been tested in an attempt to reduce these large environmental errors so that true genetic differences can be detected. Some have shown promise and are being utilized as selection criteria. The following section of this report deals with three such schemes utilized the past year.

1. Field Selection

Methods: A field relatively free of nematodes was selected for this trial. Infestation was achieved by digging a hole 4 inches deep and 3 inches in diameter with a pothole digger and filling it with one liter of nematode infested soil. Seed was planted directly into the center of the nematode soil.

Eight heterozygous varieties, a uniform hybrid and an inbred (table 1) were selected for this trial. Plots were 20 feet in length with individual beets spaced two feet apart, making ten beets per plot. The ten varieties were randomized within each plot. This resulted in each variety being represented in each plot with one beet.

The nematode soil added to the first six rows contained 230 cysts per 100 grams of soil. This soil was diluted to 60 cysts per 100 grams of soil for the remaining 12 rows. Eighteen plots were selected at random to which no nematode soil was added. These served as a check to compare nematode damage.

Seed was planted May 20 and later thinned to one plant per hole on June 26. Between the time of planting and thinning, data were taken on emergence and survival of emerging seedlings. Agronomic practices, such as, irrigation, cultivation, and fertilization were the same as for other field trials.

Roots were harvested individually on October 8. Root weights and sucrose percentages were taken on each root.

The data were analyzed as a randomized block design, with plots as blocks. Means, variances, and correlations between percent sucrose and root yield were computed for each variety. Because of the correlation between means and variances for root yield, the regression of variances on means from the non-segregating populations was used to estimate the environmental variances for the segregating populations (1).

Using these estimates for environmental variance, probabilities for genetic deviates were placed on each beet of each variety for percent sucrose, root yield, and total sucrose. These probabilities were obtained from a standard t table and are the probabilities of the deviations of individual beets from the mean of the variety.

Results: The mean percent sucrose, mean yield, and mean total sucrose for the ten varieties are shown in table 1. There were significant differences between varieties for all three characters. Hybrid F58-554H1 had the highest percent sucrose, however, it must be remembered that most of the other varieties were segregating for percent sucrose and had many segregates equal in percent sucrose to F58-554H1. Among the segregating varieties, Acc 107, D2, and RW 467 had the highest percent sucrose. The highest yielding varieties in root weight were Acc 107, 590-1, 590-0, D2, and B 889, while varieties Acc 107, 590-9, and D2 produced the most total sucrose.

The nematode effect on the ten varieties was also measured and is recorded in table 1. This was calculated by subtracting the mean yield of the nematode infested plots from the mean yield of the non-infested plots and dividing by the mean yield of the non-infested plots. The varieties ranged around 30 percent loss due to nematodes. C 877 was affected the least and F58-554H1 was affected the most by nematodes. The nematode population in the infested soil was high enough to cause some killing of seedlings. The varieties RW 467 and L24 had the highest percent seedlings dying while the inbred 52-305 suffered the least from seedling mortality.

The environmental and genetic variances were calculated for the eight segregating varieties for percent sucrose, root yield, and total sucrose (table 2). The probabilities for a genetic variance being random variation are also included in table 2. All varieties had a significant genetic variance for percent sucrose, however, variety 590-9 had the lowest genetic variance. This means that all varieties

were segregating for percent sucrose. Only four varieties (Acc 107, 590-9, D2, and B 889) had a significant genetic variance for root yield and were segregating for root yield. When total sucrose was considered, four varieties still exhibited a significant genetic variance. Thus, progress for total sucrose could be expected by selecting in varieties Acc 107, D2, B 889, and RW 467.

It is of interest to note that the probabilities are larger for total sucrose than for either root yield or percent sucrose, except for variety D2. This indicates that there is a difference between the segregating and non-segregating varieties in the percent sucrose times root yield relationship, since the estimates of environmental variance were obtained from the non-segregating varieties. Therefore, correlations between percent sucrose and root yield were computed for each variety (figure 1). The blocks in figure 1 are confidence intervals. Whenever a confidence interval crosses the zero line, that correlation is not different from zero at $p = .05$, and whenever two confidence intervals overlap, those two correlations are not different at $p = .05$.

Negative correlations were obtained for all ten varieties, however, varieties 52-305, F58-554H1, L24, and RW 467 were not different from zero. With the exception of RW 467, the most heterozygous varieties had the largest negative correlations while the non-segregating varieties had little or no correlation between percent sucrose and root yield. This indicates that this correlation is not environmental in nature but genetic and points out the difficulty in trying to improve both root yield and percent sucrose genetically.

Selections were made by constructing a table for each variety in which the probability for each beet being a genetic deviate for percent sucrose, root yield, and total sucrose are entered. A portion of the table for variety D2 is reproduced as table 3. The probabilities between -.2 and + .2 are entered as .5 and considered as not being different from the mean. Using these tables, beets can be selected with high probabilities of being superior genetic deviates for percent sucrose, root yield, and/or total sucrose. Because of the correlations presented in figure 1, it was difficult to find beets that were genetically superior for both percent sucrose and root yield.

From these tables roots have been selected for thermal induction and future breeding purposes.

Literature Cited

1. Federer, W., L. Powers, and M. Payne. 1963. Studies on statistical procedures applied to chemical genetic data from sugar beets. Tech. Bull. 17, Agr. Exp. Sta., Colo. State U., Fort Collins, Colo.

Table 1. Mean percent sucrose, root weight, total sucrose, percent reduction in root yield by nematodes and percent dying as seedlings for the ten varieties.

Variety	Source and Type	% Sucrose	Wt. (grams)	Total Sucrose (grams)	[a]% Reduction in Root Wt. by Nema.	% Dying as Seedlings
Acc 107	G. J. Curtis (Nema. sel.)	13.40	1239	160.22	27.5	35
590-1	C. Price (Nema. sel.)	11.02	1228	131.39	23.4	33
590-9	C. Price (Nema. sel.)	11.84	1307	151.12	19.8	33
52-305	R. Hecker (Inbred)	13.93	421	59.88	32.0	18
F58-554H1	J. McFarlane (Hybrid)	15.24	713	105.20	43.7	36
L24	C. Smith (Nema. sel.)	11.54	738	85.84	32.0	47
D2[b]	G. Coe (Heterozygous)	13.05	1369	172.15	33.0	41
C 877	Great Western Co. (Het.)	12.02	969	113.07	16.0	38
B 889	Great Western Co. (Het.)	10.14	1259	121.56	39.8	48
RW 467	H. Rietberg (Nema. sel.)	13.52	956	130.38	29.0	48
LSD .05		0.65	176	20.20		

[a] = Mean yield of non-infected plants minus the mean yield of infected plants divided by the mean yield of non-infected plants.

[b] = Budapest Poly Beta 4.

Table 2. Environmental and genetic variances and probabilities for % sucrose, yield, and total sucrose.

	%Sucrose			Weight (grams)			Total Sucrose (grams)		
	Environmental	Genetic	Prob.*	Environmental	Genetic	Prob.	Environmental	Genetic	Prob.
Acc 107	1.63	2.82	<.0005	233,086	168,446	<.0005	3,379	1,656	.001
590-1	1.63	2.54	<.0005	230,468	117,777	.0005	2,595	-183	.50
590-9	1.63	0.85	.01	249,270	46,284	.10	3,140	-580	.20
C 877	1.63	3.70	<.0005	168,826	58,992	.10	2,139	757	.05
L24	1.63	1.74	<.0005	113,848	21,568	.30	1,423	533	.05
D2	1.63	1.83	<.0005	246,026	167,767	<.0005	3,693	2,924	<.0005
B 889	1.63	2.75	<.0005	237,132	199,740	<.0005	2,363	1,571	.0005
RW 467	1.63	1.69	<.0005	165,932	48,387	.10	2,594	1,434	.001

* = Probability of genetic variance being random variation, may be read as: the probability of having a genetic variance as great or greater than 2.82 just by chance alone is less than .0005 (1 in 2,000).

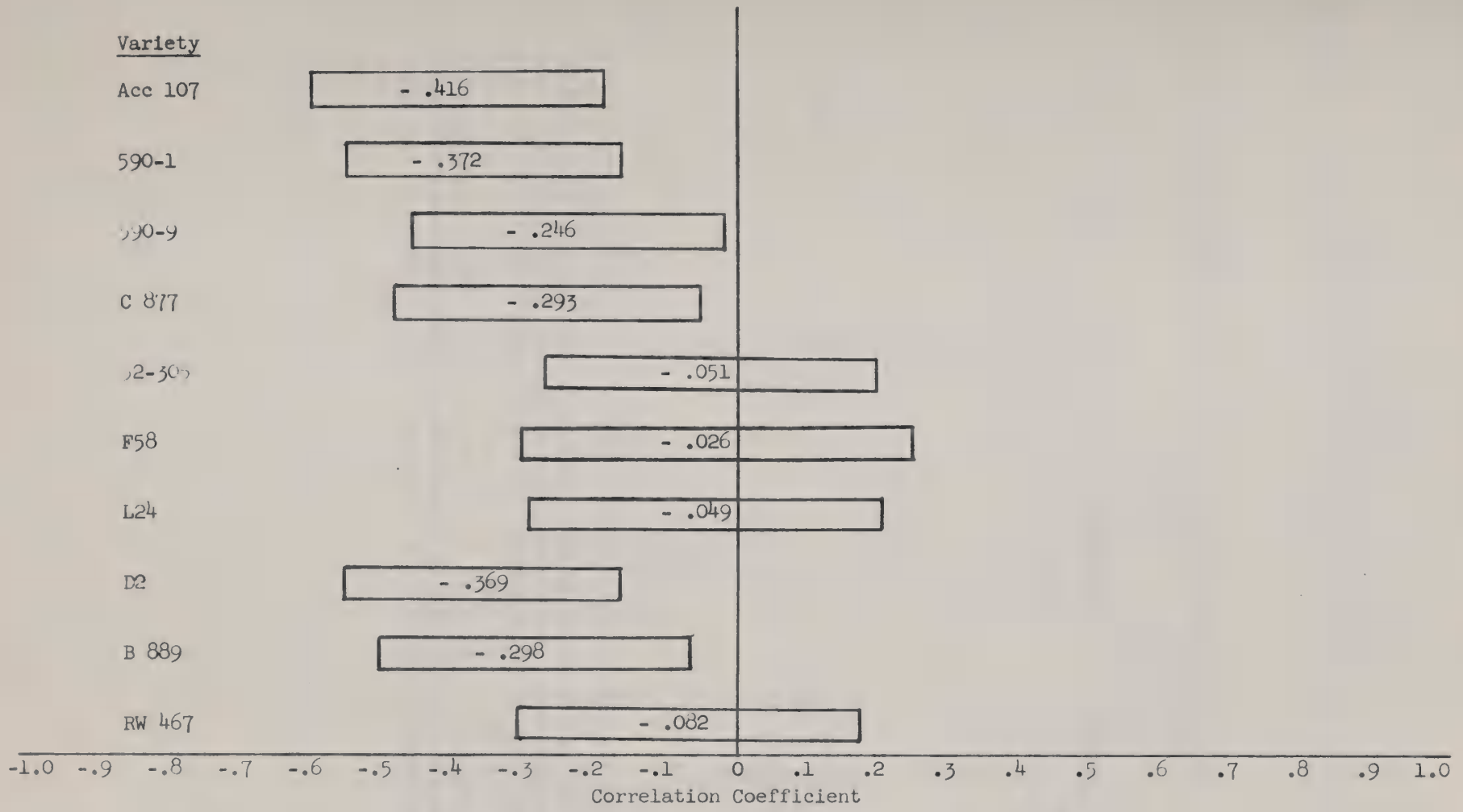


Figure 1. Correlations and confidence intervals between root weight and percent sucrose for the ten varieties.

Table 3. A portion of the D2 population showing the probabilities for individual beets for % sucrose, root yield, and total sucrose.*

Beet Number	% Sucrose	Root Yield	Total Sucrose
1	.005	- .2	.5
2	.2	- .2	- .2
3	.5	.01	.005
5	.05	.2	.05
6	.5	.2	.2
7	.5	.5	.5
9	- .05	.005	.05
10	- .2	.005	.01
11	.5	- .1	- .1
13	.1	.05	.0005
14	.5	- .2	- .1
15	.1	.5	.5
16	.5	.05	.05
18	.2	- .05	- .05
19	.05	- .2	.5
20	- .01	.5	- .2

* This table can be read (using beet number 10 as an example) as follows: The probability of another beet having as low or lower sucrose percent than beet number ten by chance alone is .2 (2 out of 10), having a root yield as large or larger than beet number ten by chance alone is .005 (5 out of 1,000) and having as much or more total sucrose than beet number ten by chance alone is .01 (1 out of 100).

2. Selection in the Seedling Stage Following Heavy Nematode Inoculation

Methods: Inoculating seedlings with large quantities of larvae at the time of emergence was found to greatly stunt or kill many of the seedlings.

In the initial studies with this technique there appeared to be a difference between varieties in the stunting and killing at this early stage of growth.

During the winter of 1968, a system of screening was conducted based on this early inoculation with large quantities of nematode larvae. Seeds were planted directly into the 85 ml plastic tubes previously used for counting white females. As soon as emergence occurred, tubes were inoculated with a series of three inoculations of 6,000 nematode larvae each at 12-hour intervals. Plants began to show stunting or dying within 7-10 days. Plants that survived this initial shock tended to recover. Data were taken each day and ratings made for each variety 10 days after inoculation.

After recovery, selections were made and transplanted into heavy infested nematode soil and allowed to grow for six weeks before re-selection. About 3,000 seedlings from seven varieties were screened in this manner. Fifty three plants survived these two selection stages and were potted in clean soil and placed in a cold room for thermal induction.

Results: The mean ratings for the seven varieties for six separate tests are shown in table 4. Each rating is the mean of 70 plants. Ratings ranged from 0 for plants that died to 5 for plants that were not stunted by nematode invasion. These mean ratings were analyzed as a randomized block design, with trials as blocks. As can be seen, there was a great deal of variation from trial to trial and when all trials were summed over there was little difference between varieties.

A similar analysis was computed for the percent of emerged plants that died 10 days after inoculation (table 5). Here again there was large fluctuations from trial to trial and varieties did not differ in percent plants dying due to nematode invasion when all trials were considered.

Several other varieties were tested on a somewhat smaller scale with about the same result as reported above.

Table 4. Ratings for each of the seven varieties for 6 tests. Each rating is the mean of about 70 plants. Ratings ranged from 0 to 5. Zero = dead and 5 = no nematode effect.

Variety	TESTS						Mean
	I	II	III	IV	V	VI	
F58-554H1	0.70	1.00	0.91	0.97	1.24	1.05	0.98
C 6600	0.77	1.45	1.22	0.21	0.86	1.44	0.99
GW 358	0.50	1.44	1.25	0.77	0.59	1.77	1.05
C 877	1.27	2.15	1.10	0.86	0.96	0.77	1.18
C 878	0.70	2.13	0.83	0.71	1.28	1.85	1.25
B 888	0.40	1.78	0.68	0.71	0.92	0.97	0.91
B 889	0.56	1.44	1.04	0.65	1.32	1.01	1.00
LSD .05							.37

Table 5. Percent of emerged plants that died for the seven varieties for six tests.

Variety	TESTS						Mean
	I	II	III	IV	V	VI	
F58-554H1	40	20	60	62	20	18	36.7
C 6600	35	6	30	77	42	17	34.5
GW 358	56	8	39	68	53	32	42.7
C 877	25	4	50	45	37	55	36.0
C 878	34	9	55	66	32	18	35.7
B 888	61	3	62	52	41	45	44.0
B 889	37	16	55	59	30	46	40.5
LSD .05							14.3

3. Effect of Fertilization on Nematode Damage and Selection

In previous experiments it has been shown that different levels of nitrogen have little effect on nematode population build-up. However, under conditions of high fertility there appears to be less nematode damage. Therefore, it was desirable to find out the effect of different levels of fertility on selection and nematode damage.

Methods: The following five varieties were selected for this study: (1) 52-305 = a highly inbred variety for an estimate of the environmental error, (2) C 877 = a heterozygous variety obtained from Great Western Sugar Company which has had no selection for nematode resistance, (3) 590-9 = a nematode selection developed by Charles Price (little heterozygosity), (4) Acc 107 = a mixture of nematode selections developed by G. J. Curtis, Cambridge, England, (5) RW 367 = nematode selection obtained from H. Rietberg, The Netherlands.

Eighty seedlings of each variety were transplanted into 8 inch pots, one-half of which had been fertilized prior to transplanting. Plants were fertilized at regular intervals the remainder of the growing period, with the fertilized pots receiving 1/4 tsp. of 10-10-10 per pot on July 26, August 6, August 20, September 3, and September 17. The remainder of the pots (low fertility treatment) received 1/4 tsp. of 10-10-10 per pot on August 20 and September 17.

Plants were arranged in a split plot design with fertilizer treatments as whole plots.

Plants were inoculated with surface sterilized larvae according to the following schedule:

9,000	larvae	per	pot	on	June 28
10,000	"	"	"	"	July 2
7,500	"	"	"	"	July 10
6,000	"	"	"	"	July 18
4,000	"	"	"	"	July 25

Eight uninoculated plants of each variety for each of the two fertility levels served as a check.

Plants were harvested November 16 and root weights taken. In addition, soil samples were taken from each pot and a cyst count made to estimate the nematode population build-up.

Table 6. Means and variances for root weight and number of cysts per 100 grams of soil in the low and normal fertilizer treatments for each variety.

	Root Weight						Nematodes	
	Low Fertilizer			Normal Fertilizer			No. of Cysts per 100 grams of soil	
	Variance	Mean	% Loss by Nematodes	Variance	Mean	% Loss by Nematodes	Low Fert.	Normal Fert.
52-305	130.6	34.7	55	155.4	59.1	25	1,076	664
C 877	392.1**	48.0	53	824.6**	86.1	34	1,172	1,042
590-9	240.8*	57.6	51	776.7**	103.1	3	1,098	806
Acc 107	1,026.9**	63.2	49	1,057.5**	99.9	14	730	414
RW 367	274.7*	72.6	52	1,707.9**	128.9	32	894	514
LSD .05		11.4			11.4		354	354
Mean of total		55.2[a]			95.4[a]		995[a]	688[a]

[a] = Significant difference between low fertilizer and normal fertilizer.

* = Significant genotypic variance at p = .05

** = Significant genotypic variance at p = .01

Results: Varieties 590-9 and Acc 107 did not differ from each other in yield in either fertility level, while all other varieties differed significantly from each other (table 6). The ranking in yield of the varieties was the same for both fertility levels (table 6). The four heterozygous varieties exhibited genotypic variance in both fertility levels, however, there appeared to be more genotypic variance in the normal fertility level (table 6). There was a greater percent reduction in yield due to nematodes and a significantly larger number of cysts in the low fertility level. In addition, the variety C 877 which had not been selected for nematode resistance had significantly more cysts than the varieties Acc 107 and RW 367, both of which were nematode selections.

The higher number of cysts in the low fertility level is probably the reason for the large reduction (about 50 percent) in yield due to nematodes, however, the reason for this higher number of cysts is unexplained.

The genotypic variance observed under low fertility is probably more of a genotypic variance for nematode resistance while the genotypic variance observed under normal fertility is probably more for plant vigor since there was very little nematode effect under normal fertility.

According to these data, it appears to be more desirable to select for nematode resistance under low-fertility levels.

B. Field testing

1. Nematode Field Test Trial One

Field testing for nematode resistance has for the past several years been conducted in heavily infested nematode fields with no means of comparing how the varieties being tested respond in fields not infested with nematodes.

The 1968 nematode field trial was conducted in the same experimental field as has been used the past few years, except that one-half of the field was fumigated with DD (1, 3, Dichloropropene 1, 2, Dichloropropane) in a split-plot design prior to planting.

The DD fumigant was applied by hand gun at the rate of 3 ml per foot of row down the center of each row. The entire plot was then covered with 4 mm plastic sheeting for one week. The trial was planted May 23, two weeks after the plastic sheeting had been removed. Plants were thinned to one plant per 9 inches on June 19. Plots consisted of one 20 foot row, 28 inches wide. The plot design was a split plot with six replicates. Ten varieties were selected for this trial (table 7).

Normal agronomic practices, such as, fertilization irrigation and weed control were carried on throughout the season. On two occasions, during mid-season, irrigation was withheld several days to allow good wilting symptoms to occur, and data to be taken on the resulting wilt.

The trial was harvested October 15. Data taken at harvest time were root weight and percent sucrose.

Soil samples were taken after harvest and a cyst count made. In the fumigated plot there was an average of 108 empty, 11.6 partly full, and 6.5 full cysts per 100 grams of soil. In the non-fumigated plots a mean of 122 empty, 618 partly full, and 2.9 full cysts per 100 grams was observed. It appears that the nematode population in the fumigated plots had built up to effective proportions by the end of the growing season.

Results: The varieties that had been selected for wilt resistance (RW 167, RW 267, RW 367, and RW 467) showed significantly less wilting than the remaining six varieties under nematode conditions both dates the data were taken (table 7). They also showed less wilting in the fumigated plots, but not as striking a contrast (table 7). There were highly significant differences in wilting between the nematode infected and fumigated plots on July 18, with only significant differences between these plots on August 22 (table 7). One reason for the lack of such large differences on August 22 might be that the nematode populations had built back up to an effective size in the fumigated plots by this time.

The mean root weights, percent sucrose, and total sucrose for each variety in nematode infested and fumigated plots are shown in table 8. There were large nematode effects on root yield and total sucrose (nematode vs fumigated comparison) but little or no nematode effect on the percent sucrose. There were also large differences between varieties for root weight, percent sucrose, and total sucrose in both nematode infested and fumigated plots. US 75 was poorest in both nematode infested and fumigated plots. US H7 (a commercial hybrid) did very poorly in the nematode infested plots, but in the fumigated plots it was one of the best.

Varieties 590-9, RW 167, RW 367, and RW 467 yielded well in both nematode infested plots and fumigated plots. These four varieties look the most promising for future nematode work.

2. Nematode Field Test Trial Two

Field testing is one of the most important places of the nematode breeding program. With the development of more material, more field testing area must be developed. In the summer of 1968 a new experimental field and testing technique was developed.

This field was developed by adding nematode soil to one-half of the field in a split-plot design. The soil containing one full cyst per gram of soil was added at the rate of 1,300 grams per foot of row in a furrow made down the center of each row. An attempt was made to cover this nematode soil and plant directly over it. However, in attempting to cover the nematode soil the furrows were shifted and planting was not over the nematode soil as desired.

The entries in this trial were the same as in field test trial one. Rows were 28 inches apart and plots consisted of one 20 foot row. Seed was planted May 15 in a split plot design with six replicates. Plants were thinned to 9 inches June 6. Other agronomic practices, such as, irrigation, fertilization, and cultivation were similar to other field trials. During mid-July irrigation was withheld several days in order to take wilting data. The trial was harvested October 15 and data taken on root weight and percent sucrose. Soil samples were taken after harvesting and the number of cysts counted. Very few cysts were found in the non-infected plots.

In the plots in which nematode soil had been added, a mean of 18.6 empty, 9.8 partly full, and 3.9 full cysts per 100 grams of soil was obtained.

Results: There was no difference between plots in which nematode soil was added and plots free of nematodes. One reason for this might have been the difficulty encountered in infesting the plots. The seed was not planted in or over the nematode soil, therefore, the plants were established and growing well before any nematode invasion took place. In addition, the nematode invasion was not great enough to cause a measurable effect even though nematodes were observed on the beets at harvest time.

There was little difference in wilt rating among the ten varieties except for RW 267 which showed very little wilting (table 9).

There were differences between the varieties for root yield and total sucrose, but little difference in percent sucrose (table 9).

It is of interest to note the ranking of varieties in this relatively clean field (table 9) compared reasonably well to their ranking in the nematode field (table 8). Under nematode conditions US H7 was very poor, but under nematode free conditions it ranked number one. US 75 yielded poor in both fields, while 590-9 was among the top in both fields. Likewise, RW 167 and RW 367 were among the top varieties under both conditions, but did not seem as superior in non-infested soils as they did in nematode infested soils.

Another attempt will be made in the summer of 1969 to develop new fields with uniform nematode infestation for nematode testing trials.

Table 7. Mean wilt rating for each variety in nematode infested and fumigated plots for two different dates.

Variety	Source and Type	July 18		Aug. 22	
		Nema.	Fum.	Nema.	Fum.
RW 167	H. Rietberg (Nema. sel.)	2.67	1.50	2.00	2.16
RW 267	" " " "	2.33	1.00	2.00	1.33
RW 367	" " " "	3.00	1.33	2.00	1.84
RW 467	" " " "	2.67	1.16	1.33	2.16
Acc 107	G. J. Curtis (Nema. sel.)	4.17	2.16	4.50	3.33
590-1	C. Price (Nema. sel.)	4.17	2.00	3.67	3.17
590-9	" " " "	3.33	2.16	3.17	2.83
592-7	" " " "	4.17	2.67	3.50	3.33
US 75	Open poll. variety	5.00	2.50	3.83	2.50
US H7	Commercial hybrid	4.67	2.16	4.33	3.50
Total Means		3.71	1.87	3.03	2.67

LSD .05 between varieties means = 1.10
LSD .05 between total means = 0.36

Table 8. Mean root weights, percent sucrose, and total sucrose in nematode infested and fumigated plots for each variety.

Variety	Root Wt. (lbs.)		% Sucrose		Total Sucrose (lbs.)	
	Nema.	Fum.	Nema.	Fum.	Nema.	Fum.
RW 167	29.3	35.4	15.7	15.5	4.60	5.49
RW 267	27.1	38.8	14.2	14.7	3.86	5.67
RW 367	27.2	35.1	16.8	16.1	4.58	5.66
RW 467	27.8	36.5	16.2	16.2	4.51	5.94
Acc 107	21.8	34.7	16.0	15.9	3.52	5.51
590-1	26.4	35.5	14.2	14.7	3.76	5.20
590-9	28.6	36.4	15.0	14.7	4.27	5.36
US 75	15.6	27.6	15.2	15.7	2.37	4.30
592-7	17.3	32.1	16.4	15.8	2.84	5.03
US H7	18.7	33.6	15.8	15.9	2.96	5.35
LSD .05	4.4	4.4	0.8	0.8	0.66	0.66

Table 9. Mean root weights, percent sucrose, total sucrose, and wilt rating on July 18 for the ten varieties.

Variety	Root Wt. (g.)	% Sucrose	Total Sucrose (g.)	Mean wilt rating July 18
RW 167	44.4	15.5	7.44	1.25
RW 267	39.0	15.9	6.49	0.50
RW 367	41.8	16.5	7.32	1.67
RW 467	43.0	14.5	6.35	1.42
Acc 107	45.6	16.2	7.75	1.75
590-1	46.8	15.0	7.36	1.33
590-9	48.6	15.5	7.93	1.42
US 75	40.0	15.7	6.66	1.83
592-7	41.3	15.3	6.12	1.67
US H7	49.7	15.8	8.10	1.58
LSD .05	4.5	1.5	1.51	0.60

SURFACE DISINFESTATION OF THE SUGARBEET NEMATODE LARVAE, HETERODERA SCHACHTII SCHM.

E. D. Whitney and Devon L. Doney

In Sugarbeet Research 1966 Report, techniques were described that we have found useful for the hatching and partial disinfestation of the sugarbeet nematode in large quantities for greenhouse studies. However, to study the interaction of the nematode with a specific fungus or with susceptible and resistant plants, nematodes free of all contamination are desirable. The following report presents techniques found successful in surface disinfesting large quantities of nematode larvae to be used in such studies.

Materials and methods: Nematodes for these studies were hatched as described in Sugarbeet Research 1966 Report except that the cysts were hand-picked after being wet-screened from sand in which nematode infected beets had been grown. Cysts were placed in the hatching pans for 24 hrs. using water as the liquid to eliminate any free living nematodes. The water was replaced with hatch solution for hatching. Following hatching, larvae were screened from the hatching solution with a 400 mesh screen and placed in 150 ml of water, hatch solution, or hatch solution plus 1000 ppm neomycin sulfate in a 20 x 150 mm petri dish. The sterility of the larvae was tested by inoculating two or more of the following media with one ml of a 10^{-1} dilution of nematode larvae suspension: potato dextrose agar, N I H thioglycollate agar, nutrient dextrose agar, 9 ml of N I H thioglycollate and sabouraud broth. The inoculated media were maintained at 24 C for at least 30 days before sterility readings were taken. Controls were similarly treated media except 1 ml of sterile water was added. Sterility tests were conducted on day 0, 1, 2, 3, 4, and 7 for the first 4 tests and daily for seven days on the final test with from 8 to 14 individual daily sterility tests for each of the five experiments, totaling 56 tests. All sterility tests were carried out under aseptic conditions.

The infectivity of larvae treated in water, hatch and hatch plus neomycin sulfate was determined in experiments 3 and 4 by staining with lacto phenol acid fuchin and counting the larvae infecting the roots of 3-week old sugarbeet seedlings grown in sand inoculated with 1000 larvae seven days prior to staining.

Results: Only one in 56 individual tests from five experiments was found containing contaminated larvae when treated for seven days with hatch plus neomycin sulfate in contrast to 17 individual tests having contaminated nematodes from bacteria or fungi or both when treated with hatch alone, table 1. The controls remained sterile. The increase in the number of individual tests remaining sterile 30 days after inoculation for the two solutions with increasing length of treatment is shown in figure 1.

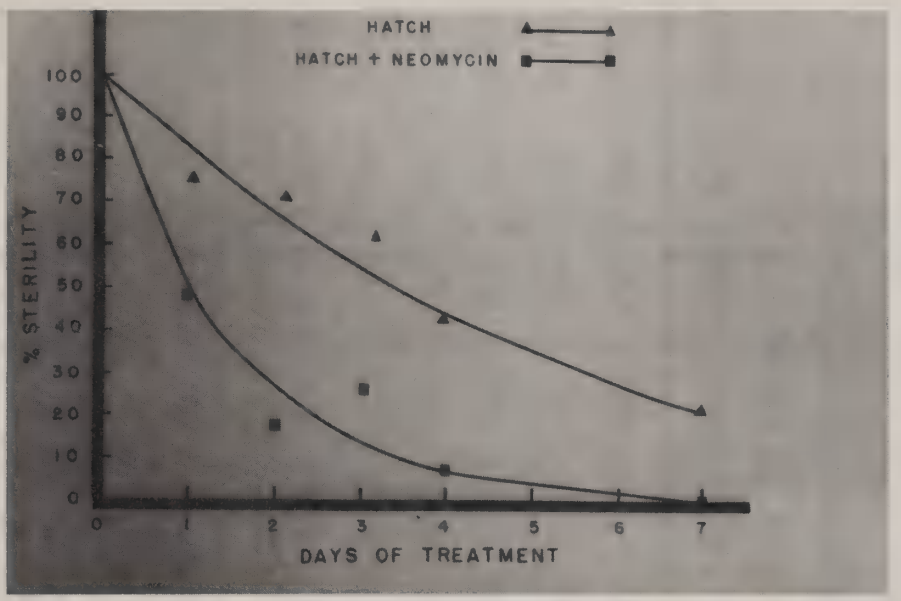


Fig. 1. Comparison of hatch solution and hatch solution plus neomycin sulfate on the disinfestation of larvae with increased length of treatment. Each point the mean percent of 5 tests, totaling 56 individual tests.

The total number of nematodes surface sterilized in experiments 3, 4, and 5 was 61,000; 17,500, and 160,000 respectively. The mean number of nematode larvae per individual sterility test with broth in experiment 5 was 95. The mean percent of larvae infecting sugarbeet seedlings seven days after inoculation when treated for seven days with water, hatch solution or hatch solution plus neomycin sulfate prior to inoculation was 30.2, 25.8, and 30.7 respectively, table 2.

There was no difference between treatments when the data were analyzed statistically for differences in the infectivity of the treated larvae.

Discussion: These data show that large quantities of surface disinfested nematodes can be obtained within seven days without loss in the infectivity of the larvae. Although several days are needed to obtain surface sterilized nematodes, the procedures are simple and require no elaborate equipment. Preliminary investigations indicate that the efficiency of the sterilization process can be increased by washing the nematode larvae twice in sterile water between hatching and surface disinfestation. The quantity of nematodes surface sterilized is dependent only on the availability of newly formed cysts. Cysts are obtained easier when produced on plants grown in nutrient sand culture than from soil.

Table 1. The effect of hatch solution and hatch plus neomycin sulfate solution on the sterility of nematode larvae following 7 days of treatment as tested by 5 media 30 days after inoculation.

	Treatments											
	Hatch[a]						Hatch + neomycin sulfate[b]					
	Test media						Test media					
Test	PDA[c]	NIHTA	NDA	NIHTB	SB	Total	PDA	NIHTA	NDA	NIHTB	SB	Total
1	0/2[d]			0/4	0/4	0/10	0/2			0/4	0/4	0/10
2	2/2			2/4	0/4	4/10	0/2			0/4	0/4	0/10
3	1/2	1/2	0/2	0/4	0/4	2/14	0/2	0/2	0/2	0/4	0/4	0/14
4	1/2	1/2	1/2	0/4	0/4	3/14	0/2	0/2	0/2	0/4	0/4	0/14
5				4/4	4/4	8/8				1/4[e]	0/4	1/8
Total	4/8	2/8	1/4	6/20	4/20	17/56	0/8	0/4	0/4	1/20	0/20	1/56

[a] Zinc chloride 4 mM, ethoxyethyl mercury chloride, 10 ppm; dioctyl sodium sulphosuccinate, 0.01%; streptomycin sulfate, 1 mg/ml and penicillin G potassium, 1000 units/ml.

[b] Neomycin sulfate 1 mg/ml (750 micrograms neomycin base / mg).

[c] PDA Potato dextrose agar; NIHTA National Institute of Health thioglycollate broth plus 1.7% agar; NDA Nutrient dextrose agar; NIHTB National Institute of Health thioglycollate broth; SB Sabouraud broth.

[d] Number of individual tests showing contaminated larvae/number of tests.

[e] One colony which appeared to be a species of Streptomyces.

Table 2. The effect of hatch and hatch plus neomycin sulfate, compared with water on the infectivity of larvae treated for 7 days.

	Treatments		
	Water	Hatch[a]	Hatch + neomycin[b]
Test 1	304.0[c]	215.5	280.9
Test 2	300.0	299.6	332.3
$\bar{x}$ % infection	30.2	25.8	30.7

[a] Zinc chloride 4 mM, ethoxyethyl mercury chloride, 10 ppm; dioctyl sodium sulphosuccinate, 0.01%; streptomycin sulfate, 1 mg/ml and penicillin G potassium, 1000 units/ml.

[b] Neomycin sulfate 1 mg/ml (750 micrograms neomycin base / mg).

[c] Mean number of larvae infecting each of 16 plants 7 days after inoculation.

SUMMARY OF ANNUAL REPORT FOR 1968

NEMATOLOGY INVESTIGATIONS, SALINAS, CALIFORNIA

Compiled by

Arnold E. Steele

Preplant treatments of Telone and D-D Soil Fumigant were applied in the bed at 20 or 30 gal/A at depths of 10, 14, or 18 inches. Significant differences in control of Heterodera schachtii between chemicals, rates, or depths of application were not obtained. The active principle in root diffusate of Beta vulgaris was found to be dialysable and consequently, is probably an organic compound with a molecular weight of less than 15,000. Root diffusate was concentrated by vacuum distillation without loss of activity. Nutrient solution in which Beta vulgaris L. or B. patellaris Moq. had grown stimulated hatching of H. schachtii. An apparatus was designed to collect larvae hatched from cysts of H. schachtii at 4 hour intervals. Periodicity in hatching of larvae occurred in 4 tests but peak hatches did not occur at the same hour in all tests. Eggs and cysts of H. schachtii were exposed to electric potentials: exposure combinations included: 1 - 60 VDC and/or AC and .01 - 350 m.a. for 2 or 60 seconds. Sixty VDC with currents of 50 - 350 m.a. decreased hatches. None of the treatments increased hatching. Treatment of eggs or cysts at 10° C with sugar beet-root diffusate or zinc chloride subsequently increased hatching in water at 24° C. Pyridoxine hydrochloride had no effect at 10° C, suggesting its mode of action may differ from other hatching agents. Removal of eggs from cysts increased hatching but did not modify the effects of root diffusate. Data obtained in 6 years by sampling fallowed beet nematode infested soil revealed an average annual decline of 19.9%.

INTERSPECIFIC HYBRIDIZATION

Vulgaris-Patellares Hybrids

Helen Savitsky

The first and third backcross generations of vulgaris-patellares hybrids were tested for resistance to the sugarbeet nematode Heterodera schachtii in 1968. Each selected plant was tested three times. In the first test, seedlings were transplanted into soil heavily infested with nematode cysts. Plants with 1-5 females (group 1) and 5-10 females (group 2) on the roots were selected and tested the second time. In the second and third tests plants were tested in infested soil and 15 additional viable cysts were placed with each plant. The use of heavily nematode-infested soil coupled with proper temperature control permitted a severe test of the selected plants.

Tests for resistance were made with 870 b_1 plants, of these, six plants were selected in the group 1, and four plants in the group 2. Among the plants selected in the first group, two were obviously highly resistant. One of them had no females on the roots in four separate tests (Fig. 1), and the other had one female in one of four tests. Both plants selected had a good root system and resembled sugarbeets more than the wild species.

Tests for resistance was continued in the b_3 progeny in 1968. Eighteen plants selected in the first and in the second group were subjected to thermal induction and seeds were obtained in the summer and fall of 1968. Two of these plants proved to be highly resistant and were progenies of b_1 and b_2 resistant plants with the 19th chromosome which is responsible for resistance. The selected b_3 plants showed different degrees of sterility. Some of them set seed almost normally, whereas with others seed setting was reduced, and two plants were almost sterile. The b_4 seeds are now planted in nematode infested soil for further selection.

New F_1 vulgaris-patellares hybrids are being continuously produced and propagated to increase the scale of selection in the b_1 generation.

Selection of plants highly resistant to nematode in the progeny of F_1 hybrids and in the following hybrid generations represent a very important step in the process of transmission of resistance from wild species to sugarbeet. The highly resistant plants are rare in b_1 progenies obtained from F_1 hybrids, but their appearance indicates the possibility of transmitting a high grade of resistance from the wild species. They also enable the start of a new phase of work, namely, selection among the genotypes of sugarbeet to which the chromosome responsible for resistance is already transmitted.

Experiments on irradiation were started in 1968. There is no available information concerning the r dosage which has to be used for induction of chromosome breakage in beets. To find out the most effective dosage for inducing translocations, the diploid sugarbeets were exposed to X-ray irradiation in the Lawrence Irradiation Laboratory of the University of California in Berkeley. The tips of flowering branches were exposed to irradiation by 500, 800, 1000, 1200 and 1500 r. The outline of meiosis will be studied in the material irradiated by different doses. Determination of the effective r dosage is of importance for irradiation of interspecific hybrids.

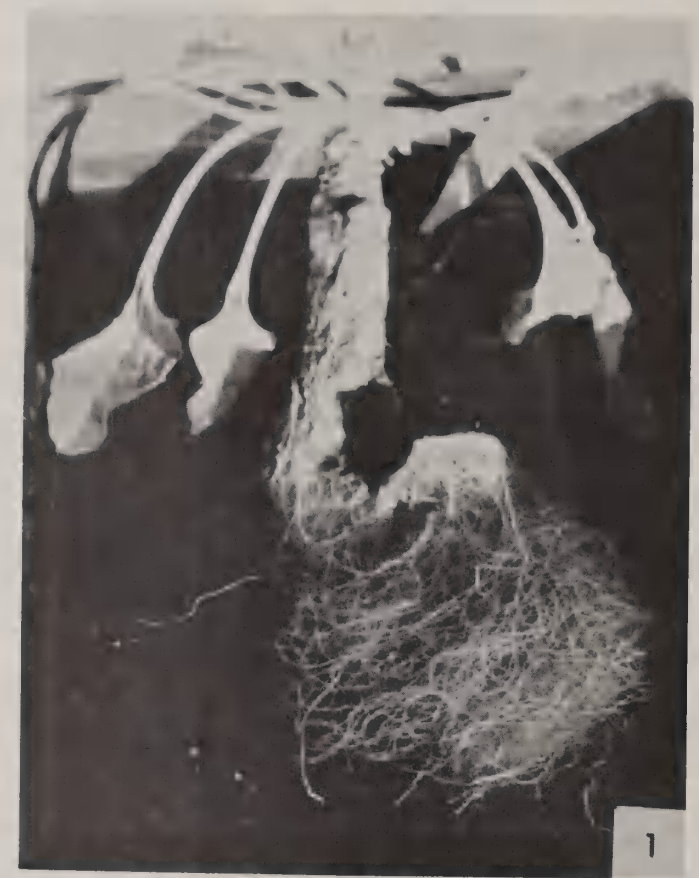


Fig. 1. A nematode resistant vulgaris-procumbens hybrid without females on the roots in 4 checks.

VULGARIS-COROLLIFLORA HYBRIDS

Helen Savitsky and C. W. Bennett

Selection for curly top resistance. The species Beta corolliflora is immune or highly resistant to curly top. To incorporate this high level of resistance into sugarbeet, Dr. V. Savitsky obtained a tetraploid (2n = 36) hybrid between tetraploid sugarbeet and tetraploid B. corolliflora. The F_1 plant was pollinated with diploid sugarbeet pollen. The b_1 plants obtained were triploid (2n = 27) or triploid aneuploids. Seedlings of the b_1 generation were inoculated by Dr. Bennett with a highly virulent strain of curly top virus. Of 400 inoculated plants 27 highly resistant b_1 segregates were selected. These plants were male-sterile and were pollinated with diploid pollen. The b_2 generation was tested for resistance by inoculating all plants in the greenhouse with highly virulent strains of curly top virus. The first inoculations were made when the plants were in the 4- to 6-leaf stage by caging about ten viruliferous beet leafhoppers on each plant. After two months or more, all plants which showed no curly top symptoms were reinoculated by placing 25 or more viruliferous leafhoppers in sleeve cages and allowing them to feed on two or more leaves of each plant for about two weeks.

The plants in the highly resistant group, which showed no symptoms, were tested for presence of virus by allowing nonviruliferous beet leafhoppers to feed on them for three days, after which the leafhoppers from each plant were caged on 12 sugarbeet seedlings of a highly susceptible selection. Curly top virus was recovered from some of the symptomless plants, but not from others, indicating that some of these plants might be immune or at least very highly resistant to curly top. The b_2 population was distributed into four groups with respect to reaction to curly top virus (Table 1) (Fig. 2).

Table 1...Distribution of b_2 Beta vulgaris x Beta corolliflora hybrids according to the grade of curly top resistance

Degree of resistance	Number of plants
Immune	19
Highly resistant	99
Susceptible	121
Very susceptible (dead)	18

The apparently immune and highly resistant b_2 plants were subjected to thermal induction and grown in the greenhouse for seed production. Male-sterility was not expressed as clearly in the b_2 population as it was in b_1 generation. Some plants produced some pollen, but the pollen grains were small and did not look viable. Therefore, the plants selected were pollinated with diploid sugarbeet pollen. The plants differed in their seed setting ability and exhibited different degrees of sterility. The b_3 seed which is harvested will be planted and the seedlings tested for curly top resistance. Additional selections will be made for resistance.

Meiosis in b_1 hybrids. The triploid b_1 hybrids were obviously derived from the gametes of F_1 plants having 18 chromosomes with nine from B. vulgaris and nine from B. corolliflora. This was confirmed by observing meiosis in b_1 hybrids. At diakinesis in b_1 hybrids usually nine bivalents formed by the chromosome of B. vulgaris and nine B. corolliflora univalents were observed. Vulgaris-corolliflora hybrids are amphidiploids and the chromosomes associated, as a rule, between identical genomes. Occasionally one or two trivalents were observed (Fig. 3). The trivalent associations including two B. vulgaris and one B. corolliflora chromosomes were of different configuration. Frequency of trivalent associations was not high. Among 70 PMCs investigated, 66 cells had no trivalents, three cells had one trivalent, and one cell had two trivalents.

At the first anaphase, some chromosomes were lagging on the spindle, and obviously were B. corolliflora univalents that moved more slowly to the poles. In spite of slower movement, the majority of them reached the poles and were included in the nuclei.

At interkinesis from 0 to 3 chromosomes remained in the cytoplasm, all others were included in the nuclei (Fig. 4). The total number of chromosomes in PMCs usually corresponded with the triploid number of 27, and the number of chromosomes in the interkinetic nuclei indicated that the univalents were transferred to the poles and included into nuclei. Of 50 PMCs in only three cells all chromosomes reached the poles and no chromosome remained in the cytoplasm. In the majority of PMCs, two chromosomes were thrown into the cytoplasm (25 PMCs) and in many cells (13) three chromosomes were in the cytoplasm.

In the second meiotic division, the PMCs usually contained the same number of chromosomes in the cytoplasm as in the first division, which indicates that the second division was quite regular.

At the tetrad stage, PMCs usually contained four big nuclei, of approximately equal size and one or two micronuclei formed by the chromosomes thrown out into the cytoplasm (Fig. 5).

The number of chromosomes was determined in the plants that were apparently immune and in some highly resistant and susceptible plants. The number of chromosomes varied in the immune and resistant plants from 20 to 25. In the susceptible group the number of chromosomes varied from 18 to 23.

Compared to the previous b_1 generation, which was triploid (2n = 27), or triploid aneuploid, the number of chromosomes of corolliflora species is reduced in the b_2 generation. At the same time the b_2 hybrids still carry two to seven chromosomes in excess of the diploid number of chromosomes in B. vulgaris. Most of these additional chromosomes are obviously the chromosomes of the wild species B. corolliflora. The majority of plants in both groups "immune" and "highly resistant" had 22 chromosomes, which probably include four chromosomes of B. corolliflora.

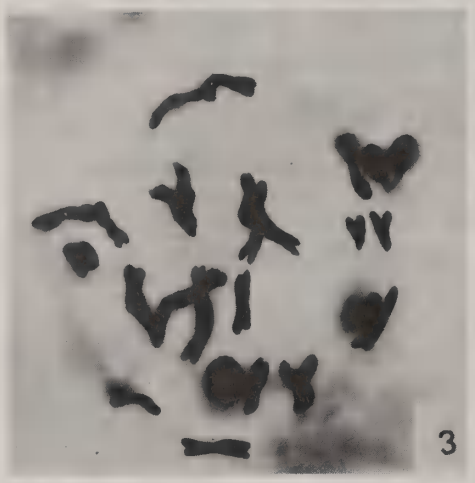
Resistance to curly top was transferred in vulgaris-corolliflora hybrids by the univalents of B. corolliflora which carried the genes providing for resistance.

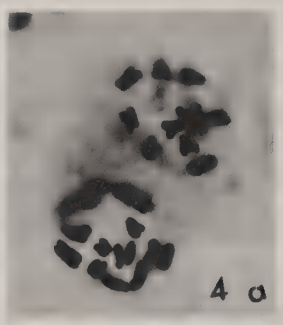
In the susceptible group many plants had 18 chromosomes and had lost all the chromosomes of the wild species. The susceptible plants with additional chromosomes obviously had the chromosomes of B. corolliflora which are not responsible for resistance.

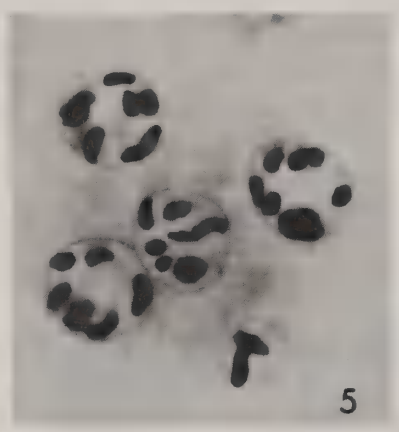
Further selection for a high level of curly top resistance will be made in succeeding generations. An attempt will be made to eliminate all chromosomes of wild species which do not carry the genes for resistance and incorporate the segments of B. corolliflora chromosomes having the genes for resistance into the chromosomes of B. vulgaris.

Fig. 2-a. Vulgaris-corolliflora b_2 hybrids resistant to curly top.

Fig. 2-b. Vulgaris-corolliflora b_2 hybrids susceptible to curly top.







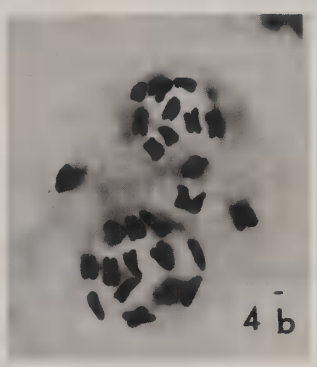


Fig. 3-5. Meiosis in b_1 3n vulgaris-corolliflora hybrids:

Fig. 3 Diakinetic nucleus having 1_{III} 8_{II} 8_{I}.

Fig. 4-a. Interkinesis - chromosome distribution in the nuclei 16:11, no chromosomes in the cytoplasm.

Fig. 4-b. Interkinesis - chromosome distribution in the nuclei 13:11, 3 chromosomes in the cytoplasm.

Fig. 5. A tetrad.

STUDIES IN POLYPLOIDY

Helen Savitsky

Ovule development and fruit germination were studied in reciprocal 2n x 4n crosses in self-sterile beets in 1967. These experiments indicated the advantage of using tetraploid plants as female parents. The tetraploid beets used as parents in triploid matings had fewer aborted ovules and better fruit germination than the diploid female parents in reciprocal crosses.

In 1968 the experiments were conducted with diploid and tetraploid male-sterile lines to investigate the viability of 3n seeds developed on diploid and on tetraploid male-sterile plants.

Fifty-nine plants of the diploid male-sterile line No. 91 and 30 plants of diploid male-sterile line No. 129 were bagged in the greenhouse and pollinated with tetraploid beets. Correspondingly, 43 plants of tetraploid No. 91 male-sterile line and 33 plants of tetraploid No. 129 male-sterile line were pollinated by diploid beets. Diploid and tetraploid pollinators were self-sterile multigerm beets taken from different populations.

Seed harvested was tested for germination and ovule development. Fifty seeds from each plant were tested for germination. Ovules were examined in the remaining seeds when available. For germination a random sample of seed was taken from each plant. The seeds were washed in water for three hours, positioned between two layers of wet blotting paper, and placed in the oven for germination. Temperatures of 68° F. for 16 hours and 86° F. for six hours were maintained. Sprouts were counted in three, seven, and ten days.

Ovules from 50 fruits per plant were analyzed. Dry seeds were opened and those which had white starch were considered to have normal ovules. The empty ones were regarded as having aborted ovules. The method of ovule examination in dry fruits was used as a precaution to maintain enough seed for germination. Ovules were examined after a seed sample was taken for germination. This method differed from that used previously with self-sterile and with male-sterile open pollinated plants as also with bagged self-sterile plants. With this method, the ovules were examined in almost mature, but not dried fruits, which were taken from the branches of growing plants. After removing the cap from a flower, an analysis could be made of the grade of ovule development (the grade of filling of the ovary) and the plumpness, or shriveling of the ovule.

In diploid male-sterile lines, ovules were examined in 4050 fruits and 4450 fruits were tested for germination (Table 2). In tetraploid male-sterile lines 3200 fruits were examined for ovule development and 3800 fruits were tested for germination. Both diploid male-sterile lines No. 91 and No. 129 had fewer aborted ovules (18.20%) than their

Table 2...Ovule development and fruit germination in triploid matings - 2n male-sterile lines x 4n pollinators and 4n male-sterile lines x 2n pollinators.

Matings	Fruits (ovules) examined	Ovules per 50 fruits				Fruits tested for germination	Sprouts per 50 fruits	
		Normal		Aborted				
		Number	Percent	Number	Percent	Number	Number	Percent
2n 91 MS x 4n MM	2650	2194	82.79	456	17.21	2950	1496	50.71
2n129 MS x 2n MM	1400	1119	79.93	281	20.07	1500	494	32.93
Total	4050	3313	81.80	737	18.20	4450	1990	44.72
4n 91 MS x 2n MM	1650	1245	75.45	405	24.56	2150	925	43.02
4n129 MS x 2n MM	1550	870	56.13	680	43.87	1650	743	45.03
Total	3200	2115	66.09	1085	33.91	3800	1668	43.89

t calculated for aborted ovules in 2n and in 4n male-sterile lines = 5.3

t tabulated at 0.05 0.01
1.994 2.698

t calculated for sprouts obtained in 2n and in 4n male-sterile lines = 0.18

t tabulated at 0.05 0.01
1.990 2.638

tetraploid equivalents, in which 33.91% of the ovules were aborted. The larger value of the calculated t than the tabulated t indicates the significance of difference.

There was no significant difference in percent of sprouts obtained from diploid (44.72%) and from tetraploid (43.89%) male-sterile lines. The value of calculated t is lower than the value of tabulated t.

The higher percent of aborted ovules in tetraploid male-sterile lines contradicts the data obtained in self-sterile plants. This contradiction may be partially caused by the method used for ovule examination. When dried fruits are examined, the group of empty fruits may include a fraction of unfertilized or sterile ovules which died at early stages or even before the embryo started to develop. The number of such ovules is much higher in tetraploids than in diploids. On the other hand, the results obtained in self-sterile beets may not be applicable to male-sterile lines that are inbred. It is highly probable that some homozygous genes cause fruit nonviability in inbred lines developed from self-sterile lines, an occurrence well known in other crops (rye, corn, etc.). Some deleterious genes may cause even greater negative effects in tetraploids.

Experiments conducted in 1967 showed great variability in the development of fruits between individual plants within diploid male-sterile lines. This variation was even greater when seed was produced in bags. All male-sterile diploid and tetraploid lines contained plants in which almost all ovules were normally developed. In such plants 46, 48, and 50 ovules of 50 examined ovules were normal (Table 3). However, within these lines plants existed with very poorly developed ovules. The number of aborted ovules in some plants reached 42 and 43 of 50 examined fruits. A great variation was also observed in germination tests. Fruits of some plants did not germinate at all. Usually only a few fruits were set on such plants. On the contrary, in other plants of the same line 48, 50 fruits of 50 fruits tested germinated.

The tetraploid male-sterile lines used as female parents in this experiment did not show an advantage over diploid male-sterile lines when used as the female parent. At the same time, in tetraploid, as well as in diploid male-sterile lines, plants were observed with excellent fruit viability. In many plants 70-80 percent of fruits germinated and the plants having 90 percent germination were not an exception. But the presence within a male-sterile line of plants with low fruit viability decreased the average evaluation of the line. This indicates that male-sterile diploid and tetraploid lines should be selected for better fruit viability. The improved male-sterile diploid lines, as well as their improved pollinators, could than be turned into tetraploids. Because of the theoretical and practical importance of male-sterility, the study of male-sterile lines will be continued.

Table 3...Variation in the number of normal and aborted ovules and in the number of sprouts obtained between individual plants within 2n and 4n male-sterile lines in triploid matings.

Matings	Ovules		Sprouts
	Normal Minim.-Maxim.	Aborted Minim.-Maxim.	Minim.-Maxim.
2n 91 MS x 4n MM	7-50	0-43	0-48
2n129 MS x 4n MM	25-48	2-22	0-42
4n 91 MS x 2n MM	20-48	2-30	0-44
4n129 MS x 2n MM	8-46	4-42	1-48

SUGARBEET VIRUS DISEASES IN CENTRAL ARIZONA NOVEMBER 1967 TO JUNE 1968

E. G. Ruppel

Virus disease surveys which were begun in 1965-66 (Sugarbeet Research 1966 and 1967) were conducted again during the 1967-68 sugarbeet campaign. The experimental methods were identical to those reported earlier (Sugarbeet Research 1967). Briefly, monthly observations were made in 29 commercial fields and one experimental field in Maricopa County. Disease incidence was assessed by counting diseased plants in 20 samples of 50 plants each, situated along two random diagonals of the fields. All fields were planted with Spreckels' monogerm, curly-top resistant sugarbeet 'S301-H' in September-October 1967.

RESULTS

The relative incidences of all virus diseases were identical to those reported for 1965-66 and 1966-67 (Sugarbeet Research 1966 and 1967). That is, yellows was the most prevalent disease followed by curly top, cucumber mosaic, yellow vein, and beet mosaic, respectively (Table 1). The last four named diseases were observed only in trace amounts.

The incidence of yellows closely paralleled the incidence observed in the 1966-67 surveys and reached 100% by June; curly top incidence, however, was much lower than that observed last year. Figure 1 graphically presents the incidences of yellows and curly top for the past three years.

Table 1.--Monthly mean incidences of sugarbeet virus diseases in 30 fields in central Arizona (Maricopa County), November 1967 to June 1968.

	Percentage diseased plants[a]							
Disease	Nov	Dec	Jan	Feb	Mar	Apr	May	June[b]
Yellows[c]	TR[d]	5.3	33.5	76.4	92.0	92.6	99.6	100.0
Curly top	5.0	2.7	2.1	.8	.9	2.4	1.9	.9
Cucumber mosaic	0	TR	TR	TR	TR	TR	TR	TR
Yellow vein	TR	0	TR	TR	TR	TR	TR	0
Beet mosaic	0	0	TR	TR	0	0	0	0

[a]Percentages based on a 1000-plant sample per field.
[b]Only 16 fields included; 14 fields harvested.
[c]Includes both beet and western yellows.
[d]TR = less than 0.1%.

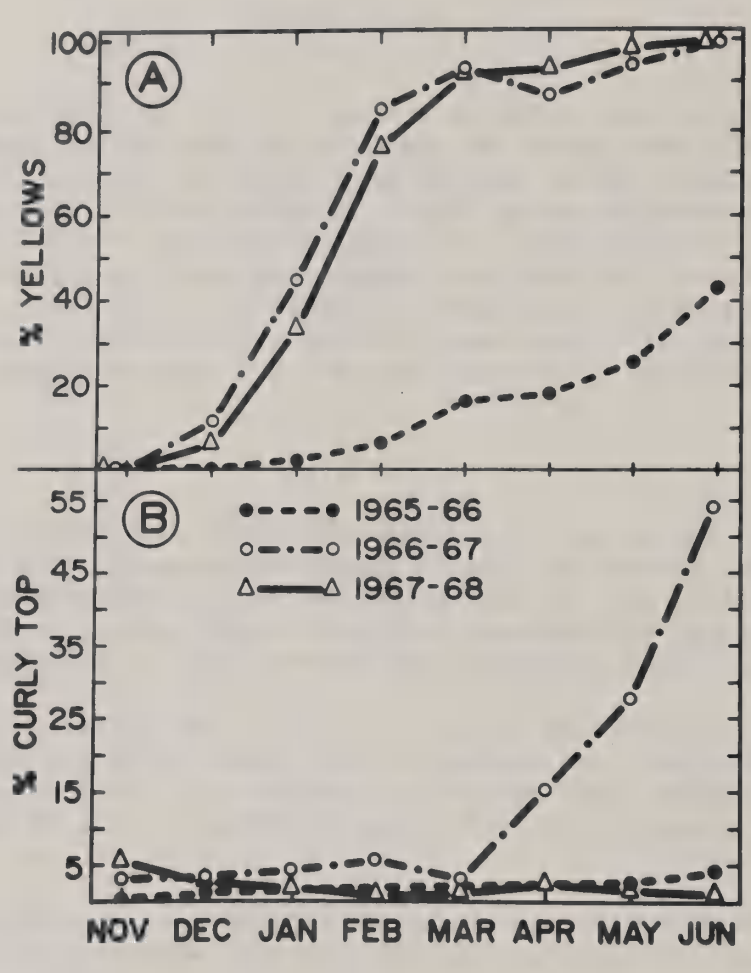


Figure 1.--Mean monthly incidence of sugar beet yellows (beet and western) and curly top in central Arizona from November through June in 1965-66, 1966-67, and 1967-68; A, yellows incidence, and B, curly top incidence.

DISCUSSION

Like the 1966-67 season, the early appearance and persistency of green peach aphids (Myzus persicae (Sulz.)) resulted in an early and rapid buildup of yellows. Also, increased sugarbeet acreage provided an abundant source for secondary spread of the virus after initial infections were established.

The apparent decrease in curly top as the season progressed was an indication of the recovery phenomenon of resistant beets. Visual observations late in the season were inadequate for detecting infected plants.

The obvious decrease in curly top incidence and severity from that observed in 1966-67 is not easily explained. Leafhoppers were abundant throughout the 1967-68 season, and isolates of the virus collected in February proved to be more virulent than strain 11 and almost as virulent as the Los Banos strain of curly top from California (McFarlane, personal communication). Apparently, factors other than the presence of leafhoppers and highly virulent strains of the virus are necessary for the development of severe curly top epidemics in central Arizona.

SUMMARY

Monthly disease surveys conducted from November 1967 through June 1968 revealed yellows (beet and western) as the most prevalent virus disease of sugarbeets in central Arizona for the third consecutive season. Incidence of yellows paralleled that observed in 1966-67 and reached 100% by June. Curly top was second in prevalence, but its incidence was much lower than in 1966-67. Only trace incidences of cucumber mosaic, yellow vein, and beet mosaic were observed.

RELATIVE INCIDENCES OF BEET AND WESTERN YELLOWS VIRUSES IN CENTRAL ARIZONA IN 1967-68

E. G. Ruppel

Visual symptoms in the field were inadequate for distinguishing between sugarbeets infected with beet yellows virus (BYV) and those infected with beet western yellows virus (BWYV). Therefore, samples were collected from yellowed beets throughout the season and indexed to indicator hosts of the virus in the greenhouse to determine the identity, relative incidence and seasonal buildup of the two viruses. Materials and methods were the same as previously reported (Sugarbeet Research, 1966). A total of 302 samples from 30 widely scattered fields in Maricopa County were indexed between November 1967 and June 1968.

RESULTS

For the third consecutive year results of the indexings indicated that BWYV was the most prevalent yellows-inciting virus in central Arizona. The virus was recovered from 90% of the samples. BYV was not detected until May, and only in mixed infections with BWYV. In May, 16% of the samples were infected with BYV; in June, the virus was recovered from 27% of the samples. BYV was recovered from only 4% of the 302 samples. Comparison with indexes of previous years is presented graphically in Figure 1.

DISCUSSION

For three consecutive years the relative incidence of the two yellows viruses has remained about the same, and BYV has not been detected earlier than April. If this trend continues, losses due to the additive effects of both viruses should be minimal. Nevertheless, cultural practices (e.g. field cleanup of beets, maintenance of a beet-free period) that prevent the carry-over of BYV in reservoir hosts (mainly beets) from season to season should be followed.

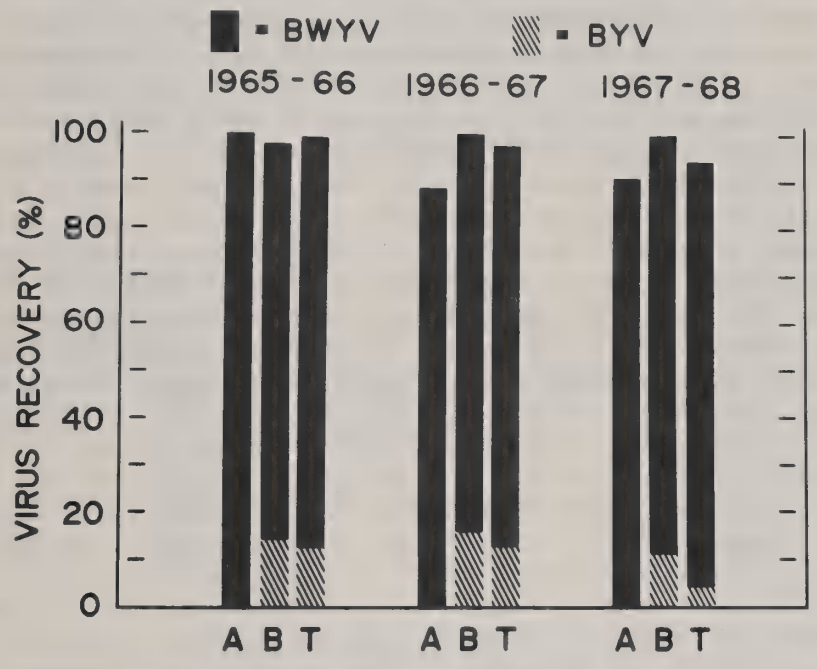


Figure 1.--Percentage recovery of beet yellows virus (BYV) and beet western yellows virus (BWYV) from field sugar beets showing foliage yellowing in central Arizona from November through June 1965-66, 1966-67, and 1967-68; A, indexes made from November through February, B, indexes made from March through June, and T, total results.

DISEASE OBSERVATIONS IN SUGARBEETS GROWN AT HIGH ELEVATIONS IN ARIZONA

E. G. Ruppel

In the lower elevations of central Arizona sugarbeets are planted in September and harvested the following May through July. To extend factory operations, growers were contracted in 1967 in the higher elevation areas of Graham and Cochise Counties where beets were planted in February and harvested in October-November. Thus, Arizona sugarbeets are grown at elevations from about 700 feet to 4200 feet under a wide variety of climatic and environmental conditions. To gain some insight on the epidemiology, etiology, and economic importance of the diseases that occur in sugarbeets grown in the higher elevation areas, observational surveys of several fields in Graham and Cochise Counties were conducted on July 23-24 and September 11-12, 1968. All fields, except for one small variety trial, were planted with Spreckels' monogerm, curly top resistant variety 'S301-H'.

VIRUS DISEASES

Curly Top

Curly top was the most prevalent virus disease encountered in all fields in July and in most fields in September. Incidence of this disease varied from about 1 to 40%, with the heaviest and most severe infection occurring in Graham County. Fields where beets seemed to be subjected to greater stress (i.e. weed competition, poor cultural practices, poor nutrition, inadequate water, other diseases) exhibited the highest incidence and most severe symptoms of curly top. The severity of symptoms in relatively large beets might indicate the presence of highly virulent strains of the virus. Such strains have been found in central Arizona (McFarlane, personal communication).

Yellows

In July, less than 1% yellows was observed in any field; however, by September, 10 to 90% of the beets in Cochise County were infected. Incidence remained low in Graham County. Green peach aphids could not be found on beets or nearby weeds in July or September. Apparently. infection took place sometime in June and the symptoms were not yet evident in July.

A limited number of samples were collected from yellowed beets in July and September. These were indexed in differential hosts in the greenhouse

to identify the causal yellows virus. Beet western yellows was recovered from all samples. Beet yellows virus was not detected; however, due to the small number of samples indexed, it cannot be concluded that the virus was not present in the high elevation areas.

FUNGUS DISEASES

Root Rots

Root rots of relatively large beets (ca. 5 months old) incited by Rhizoctonia solani Kuehn and Pythium aphanidermatum (Edson) Fitzp. were observed in high-elevation beets, primarily in Graham County. Another rot, incited by Sclerotium rolfsii Sacc. was observed in 1 field in Cochise County. Incidence of Pythium rot varied from 2 to 50% between those fields with obvious infection; some fields apparently were free of this disease. Rhizoctonia rot was present in low incidence in most fields but the infected beets were not seriously damaged. Microscopic and isolation techniques were used to identify the causal organisms; pathogenicity tests ascertained their ability to incite disease in sugarbeets.

Leaf Spots

Cercospora beticola Sacc., Ramularia beticola Fautr. & Lambotte, and Phoma betae Frank were isolated and identified from leaf spot-infected beets.

Of the leaf diseases, only Cercospora leaf spot appeared to be of economic importance in higher-elevation beets. The disease first was evident in very low incidence in July shortly after the onset of summer rains. By September the leaves of most plants were covered with typical Cercospora lesions.

Ramularia leaf spot first was observed late in autumn (1967) when the beets were approaching harvest. This disease was not observed in the 1968 surveys. Apparently, the relatively higher summer temperatures were unfavorable for development of this disease. Thus, this leaf spot should not pose a serious threat to sugarbeets in the higher elevations of Arizona.

Phoma leaf spot was observed only in a few fields. Incidence was low and the disease probably will not become serious in this area.

Rust, powdery mildew, and downy mildew have not been observed in beets grown in the higher elevation counties.

NEMATODES

Root knot nematodes (Meloidogyne incognita (Kofoid & White) Chitwood) are a potential threat to sugarbeet production in the higher elevations of the State. The usual practice of using cotton and sorghum in rotations with beets also may serve to increase soil populations of this nematode. Although incidence of root knot in 1968 apparently was lower than in 1967 (Brickey, personal communication), heavy losses can be expected in those fields where infestation was high.

DISCUSSION

Curly top, Pythium root rot, Cercospora leaf spot, and root knot currently are the most serious diseases of sugarbeets at the higher elevations of Graham and Cochise Counties. Yields of beets grown in these areas have been unexpectedly low, conceivably due, in part, to the devastating effects of one or more of these diseases. Methods will have to be devised and tested toward bringing these threats to sugarbeet production under control.

Resistant varieties and chemicals may afford some control of leaf spot. Test strips of beets sprayed with systemic or topical fungicides in Graham County had less leaf spot than non-sprayed checks. However, leaf spot still was prevalent in the treated areas which indicated that time, number, and rate of applications need to be evaluated for more effective control. In one field trial several Cercospora resistant varieties had less leaf spot than the susceptible controls. These varieties have not been fully evaluated in regard to their yield potential in Arizona.

Soil fumigation was tested against root knot nematodes in one field that had a high incidence of root knot the previous season. In July roots of fumigated beets were almost free of root knots, whereas non-treated beets were heavily infested and dying. By September, however, even the beets in the treated areas were heavily diseased. Crop rotation, summer fallow with deep plowing, and more efficient and higher-dosage application of soil fumigant might keep this disease under control.

Pythium root rot, perhaps, will be the most difficult disease to control. The fungus persists in the soil for extremely long periods and its host range is large. Any measures that help avoid excessive soil moisture conditions, such as proper field leveling and avoidance of over-irrigation, should be practiced (1).

Current resistant varieties probably will prevent catastrophic losses due to curly top infection. Field trials with thimet under the seed also may prove worthwhile in checking the early buildup of virus and leafhoppers (Burtch, personal communication).

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SUMMARY

Diseases observed in sugarbeets grown at the higher elevations of Graham and Cochise Counties in Arizona included curly top, yellows, Rhizoctonia, Pythium, and Sclerotium root rots, Cercospora, Ramularia, and Phoma leaf spots, and root knot. Of these, curly top, Pythium root rot, Cercospora leaf spot, and root knot appear to be the greatest threats to sugarbeet production in these areas.

TESTS TO DETERMINE ROOT ROT POTENTIAL OF SUGARBEET FIELDS

E. G. Ruppel

One of the most serious threats to sugarbeet production in the higher elevation areas of Graham and Cochise Counties in Arizona is a rot of mature beets incited by Pythium aphanidermatum (Edson) Fitzp. (2, 4). The fungus persists for long periods in the soil, and no genetic resistance to the pathogen has been found in the varieties of beets presently being grown. Therefore, control of this disease cannot be achieved at present through crop rotation or through the use of resistant varieties. One possible control measure would be to avoid fields that have a high infestation of the causal fungus.

A greenhouse technique for estimating the degree of infestation by Aphanomyces euteiches Drechs. of pea fields before planting has been quite successful in Wisconsin (5). This technique and a soil-dilution-frequency technique were evaluated to determine if the root rot potential of beet fields could be measured similarly.

METHODS AND MATERIALS

Greenhouse Test

Disease surveys were conducted in July and September 1968 to determine the incidence of Pythium rot in several beet fields in Graham and Cochise Counties. In September, 4 fields were selected that had an estimated range of root rot from 0 to 50%. About 6 liters of soil were collected to a depth of 15 cm at 10 random locations in each field. The soil was placed in polyethylene bags for transportation to the greenhouse. In the greenhouse, each soil sample was placed on clean wrapping paper and thoroughly mixed by hand with peat moss (1:4 v/v). Three 6-in clay pots were filled to within 1 inch of the rim and 10 sugarbeet seeds of Spreckels' monogerm variety 'S301-H' were planted in each pot. Additional check plantings also were made which included: (1) steam pasteurized greenhouse potting soil; (2) potting soil to which was added an isolate of P. aphanidermatum from Graham County; (3) potting soil to which was added an isolate of Rhizoctonia solani Kuehn from Graham County; (4) potting soil to which was added P. aphanidermatum and R. solani. Inocula for the last 3 check plantings consisted of 6-week-old sand-oatmeal cultures (200 g white silica sand:20 g ground oatmeal: 50 ml distilled water). One culture was mixed thoroughly with the soil from 3, 6-in pots. Where both isolates were used 1 culture of each fungus was mixed with the soil from 3 pots. All the pots

were covered with a thin layer of vermiculite to retard algae and placed in a randomized complete block design on the greenhouse bench. The pots were irrigated as needed until the seedlings had emerged. After emergence the soil in all pots was held at or near saturation for 10 days by heavy daily watering. Thereafter, soils were kept at normal moisture until final readings were taken 21 days after planting. Greenhouse temperatures were maintained between 26 and 32°C.

Soil-Dilution Plate Technique

A soil-dilution plate technique as described by Johnson et al. (3) was modified and used to determine the relative populations of pythiaceaous fungi present in the field-soil samples used in the greenhouse test described above. The moisture content of the 4 field soils and the greenhouse soil containing Pythium was determined with 50- to 60-g aliquots of each. Soil dilutions were made by placing 25 g of soil (dry weight basis) in a 250-ml graduated cylinder. Sterile distilled water was added to obtain a total volume of 250 ml. The suspension was stirred and then transferred to a 1000-ml Erlenmeyer flask. The flask was placed on a mechanical shaker for 1 hr. Ten ml of this suspension (while in motion) was drawn into a sterile 10-ml pipette and transferred to an 8-oz prescription bottle containing 90 ml sterile distilled water. The suspension was shaken by hand and 10 ml of this dilution (1:100) then was transferred to another 90 ml sterile water blank to give a final dilution of 1:1000 (w/v). One ml of the 1:1000 dilution was transferred to each of 6 Petri dishes containing solidified corn meal agar to which had been added 50-100 ppm of polymyxin-B-sulfate and penicillin G (sodium), and 100 ppm pimaricin before the plates were poured. This media is specific for pythiaceous fungi (1). The dishes were rotated by hand to disperse the soil suspension and then arranged in a randomized complete block design within a B.O.D. incubator held at 25 C. Colony counts were made in 3 days. To obtain fungus propagules per 1000 g of soil the average number of colonies per dish was multiplied by 1000. Treatments (soil dilutions) were replicated 6 times in each of 2 separate trials.

RESULTS

Greenhouse Test

Seedling survival 14 and 21 days after planting was used to estimate the root rot potential of the test soils (Table 1). Survival of seedlings grown in soil artificially infested with either Pythium or Rhizoctonia was extremely low. No seedlings emerged from soil with added Pythium,

and only 1-2 seedlings emerged from soil in the treatments incorporating Rhizoctonia. As expected, seedling survival in soil collected from the field that had the highest incidence of Pythium rot (Shirley) also was lower than the survival in all other field soils. Seedling survival in soil collected from the Claridge field where no Pythium rot was detected was only 62% of the control at 21 days. Survival in soil from the Mettice and Malloy farms was greater than the control.

Table 1.--Survival of sugarbeet seedlings grown in soil artificially infested with Pythium aphanidermatum or Rhizoctonia solani or both, and in soil collected from 4 sugarbeet fields.

Soil source[a]	Survival[b] 14	21	Pythium rot in field
	%	%	%
G + P	0	0	---
G + R	8.3	7.7	---
G + P + R	8.3	15.4	---
Shirley farm	41.7	53.8	50
Claridge farm	66.7	61.5	0
Malloy farm	150.0	138.5	2
Mettice	150.0	146.2	10

[a]G = greenhouse soil, P = P. aphanidermatum, R = R. solani.
[b]Based on percentage of control seedlings grown in greenhouse potting soil at 14 and 21 days after planting; average of 3 replications.

Soil-Dilution Plates

The number of pythiaceous propagules per 1000 g of soil in 2 trials is presented in Table 2. The results of the plate test did not correlate with the incidence of Pythium rot in the field. No Pythium rot was observed in beets on the Claridge farm, but soil from this field ranked second in number of colonies in both trials. Conversely, soil from the field with the highest incidence of rot (Shirley, 50%) produced the fewest colonies in trial 1, and ranked third (in 4 field soils) in trial 2. The highest number of colonies in both trials occurred in the soil dilution from the Mettice field. This field had a 10% incidence of Pythium rot when the soil was collected.

Table 2.--Propagules of fungi from greenhouse soil artificially infested with Pythium aphanidermatum and soil from 4 sugarbeet fields as determined by a soil-dilution plate technique which incorporated an antibiotic medium specific for pythiaceous fungi.

Soil source	Propagules/1000 g soil Trial 1	Trial 2	Incidence of Pythium rot
			%
Mettice field	5000	4330	10
Claridge field	3670	1833	0
Malloy field	1170	830	2
Shirley field	830	1170	50
Greenhouse + Pythium	0	170	---

DISCUSSION

It is possible that the greenhouse technique might be used to determine in advance of planting the root rot potential of prospective sugarbeet fields. But, several tests would have to be conducted to correlate greenhouse damping-off data with the observed root rot incidence in the field. Then,a selected level of seedling damping-off could be used as the criterion to determine whether or not a certain field should be used for sugarbeets.

There are two major disadvantages to the greenhouse technique. First, the method requires relatively large samples of soil, a greenhouse, and a fulltime technician who can process the soil samples. Second, the method is not selective for any one potential pathogen. The conditions established in this preliminary test included high air and soil temperatures and excessive moisture in the greenhouse pots. Such conditions are ideal for the development and infection by P. aphanidermatum but may retard or enhance the activity of other potential pathogens. Erroneous conclusions could easily be drawn. For instance, seedling survival from the Malloy soil was greater than in the control planting. However, every seedling was badly stunted and heavily infested with root knot nematodes. If seedling survival was the sole criterion for planting a field, the Malloy field would definitely be used. If the presence of root knots also was used to determine the usability of a field, Malloy's field would be rejected. Actually, a relatively low incidence of root knot and Pythium rot were observed in the Malloy field; however, advanced estimates of yield indicated that the field would produce a good crop of sugarbeets this year.

Results of the modified soil-dilution plate technique did not correlate with the observed incidence of Pythium rot in the field. The method is not specific for P. aphanidermatum and other pythiaceous fungi also develop on the antibiotic media. Identifications of P. aphanidermatum would be difficult due to the presence of contaminating bacteria, which occur although the antibiotics retard them considerably. Freeing the colonies of bacteria is a difficult chore incorporating special techniques of repeated subcultures. Further, the mere presence of P. aphanidermatum would not necessarily indicate a high potential loss in sugarbeet yields. Environmental and cultural factors play important roles in the epidemiology of Pythium rot at the higher elevations in Arizona (2).

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SUMMARY

In the greenhouse, sugarbeet seeds were planted in soil samples collected from 4 fields having a range of Pythium root rot from 0 to 50%. Seedling survival at 12 and 21 days after planting was compared to the disease incidence observed in the field. Lowest survival occurred in the field with the highest incidence of rot; however, survival in soils from fields that had 2 and 10% rot, respectively, was greater than survival in pasteurized soil. The results of this preliminary experiment indicated that a greenhouse technique might be useful in determining the root rot potential of prospective sugarbeet fields. However, more tests are needed to correlate seedling survival in the greenhouse with incidence of rot in the field.

A soil-dilution plate technique that incorporated a medium specific for pythiaceous fungi was tested to compare the number of fungus propagules in the field-soil samples with incidence of Pythium rot in the field. No correlations could be made between the number of fungus colonies that developed on the plates and the amount of rot observed in the field.

SUGARBEET RESEARCH

1968 Report

Section C

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CONTENTS

Studies of Pollen Restoration with NB-1, CT9, and SLC 129 CMS Lines

J. C. Theurer and E. H. Ottley

In the 1965 and 1966 research reports, data were presented indicating that NB-1 CMS was a stronger emasculator than SLC 129 and other lines developed at the Salt Lake Station. This past year F_2 populations from individual F_1 plants, derived from NB-1 CMS X R_f, SLC 129 CMS X R_f, and CT9 CMS X R_f, were grown in the greenhouse. The average fertility for all plants of each of the three populations, respectively, was 35.7%, 67.2%, and 61.2%. This confirms the data of previous years. The NB-1 F_2 families were grouped based on the fertility of the F_1 plants from which they were derived. Of interest was the observation that the groups of 5%, 10%, 20%, and 50% stainable pollen in F_1 showed no appreciable difference in their range in degree of fertility and sterility in the F_2. Thus, even though NB-1 showed lower average fertility, much of the difference in fertility of individual plants is of an environmental nature. There was more variation in fertility in the NB-1 lines than the 129 and CT 9, but this was expected since most of the plants in the latter two groups had 50% or higher stainable pollen.

Inheritance and Linkage Studies of Some Mutant Characters in Sugarbeets[1/]

J. R. Stander and J. C. Theurer

Inheritance and linkage relationships were studied for three mutant characters in sugarbeets: virescens, chlorina, and plantain leaf. The virescens was a different type than that described previously by Savitsky (2), and it has been designated vi_4. Virescens was observed to act as a simple recessive. Male sterility found in the original virescent mutant was found to be identical to the a_1 Mendelian male-sterile gene. Chlorinas from two sources, Dr. V. F. Savitsky's ch_2 and a mutant from irradiated SLC 03, were found to be controlled by the same gene. The inheritance of chlorina as a simple recessive was confirmed. A plantain-leaf mutant was found to be controlled by two dominant complementary genes which were designated Pl_2 and Pl_3. This is a different mutant than the recessive plantain mutant described by Owen and Ryser (1).

[1/] This study was a thesis submitted recently to the graduate school at Utah State University in partial fulfillment of requirements for the M.S. degree. Appreciation is expressed to the Beet Sugar Development Foundation for providing funds for the research assistantship which supported Mr. Stander in this study.

Linkage data showed the gene vi_4 to be independent of Y, R, B, a_1, and ch_2. The gene ch_2 exhibited independence of a_1, vi_4, and R. One of the complementary factors for plantain leaf, Pl_2, showed independence of R.

Considerable variation was observed in the expression of vi_4 and Pl_2Pl_3. There was variation noted in the amount of time required to develop normal pigmentation in the virescent plants observed and also in the coloration of virescent leaves. Intermediate inheritance was observed in the plantain-leaf mutant. One of the causes for this variation was suggested as incomplete dominance at one of the loci. It is anticipated that the full details of this study will be published in the near future.

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Viability Studies of Sugarbeet Seed in Long-Term Storage

C. H. Smith

The completion of forty years of seed storage in one experiment and thirty years in a second experiment was recorded. Seed stored forty years showed a marked decrease in germination percentage. Examination of the ungerminated seed showed no increase of empty seed balls. A high percentage of germs appeared normal but they were not decomposed, as would occur with dead seeds in environments suitable for germination. This indicated that the embryos had entered into a highly dormant condition which could not be broken with germination methods used in these tests.

Five lines of seed were used in the thirty-year experiment. Differences in germination percentages occurred among the varieties as well as between regular and cold-temperature storage of the same varieties. Heavy deterioration in germination percentage was evident in some treatments. Three lines maintained their viability better under cold storage than at regular storage. One number stored as well in normal seed storage as in cold storage.

Cold-Temperature Germination and Frost Resistance of Sugarbeet Seedlings

C. H. Smith

The work on this project consisted of a continuation of testing procedures and selection from sugarbeet lines that previously showed improvement in germination at cold temperatures and seedling resistance to frost. A field planting made March 6, 1968, consisted of parent lines and selections as well as additional lines showing promise in laboratory tests. Results indicated field studies were comparable to laboratory tests in most instances. Selections of surviving plants were made for further study.

Variety Tests, Logan, Utah, 1968

George K. Ryser, J. C. Theurer, and Myron Stout

SOIL TYPES: Silty loam on North Farm and sandy loam on Farmington Farm.

PREVIOUS CROPS: 1967, fallowed at the North Farm and 1967, tomatoes at the Farmington Farm.

FERTILIZER: North Farm received approximately 400 pounds per acre of 24-20-0 harrowed in before planting. The Farmington Farm received the equivalent of 600 pounds per acre of 24-20-0 harrowed in before planting.

PLANTING DATES: North Farm, April 30, 1968. Farmington Farm, April 16, 1968.

THINNING DATES: North Farm, June 12, 13, 1968. Farmington, May 14, 15, 1968.

IRRIGATIONS: North Farm sprinkled after planting. Sprinkled after thinning and on a weekly schedule until two weeks before harvest. Farmington, furrow irrigated approximately at weekly intervals as needed to keep field on the damp side throughout the season until two weeks before harvest.

HARVEST DATES AND PROCEDURES: North Logan tests were harvested Oct. 7-24, 1968, and Farmington tests were harvested Oct 29-Nov. 1, 1968.

Tops were removed with a rotobeater and scalped with tractor-mounted scalping tools supplemented by long-handled hoe trimming to assure a complete topping job. Beets in plots were counted when put into the weighing basket on the harvester. A ten-beet sample was taken at random from the harvester table from each row of the two-row plots for sugar analysis, and all beets in plot were weighed to determine root yield.

EXPERIMENTAL DESIGN: Test 1 consisted of 49 varieties planted at North Farm and at Farmington in a 7 X 7 balanced lattice with eight replications at each location. This test was analyzed as a randomized block design and no adjusted means were calculated.

Test 2 was an inbred test planted at Logan only in randomized block design with 4 replications and 24 varieties.

Test 3 was planted at Farmington only in a 5 X 5 balanced lattice design with 6 replications. This test was made up of single crosses with check varieties US 22/3, 7114, and U & I hybrid #7.

Test 4 was a variety screening test planted at Logan only in a 11 X 11 partially balanced lattice design with 6 replications.

Test 5 and 6 consisted of selections from individual beet progenies out of 2224 and 4702 populations, respectively. These tests, consisting of 16 progenies, were planted in randomized blocks with 6 replications.

Tests 7 and 8 were additional individual-beet selections, progenies from 4702 and 2224 populations. Test 7 consisted of 5 aa progenies selected either for high sugar, low-impurity index, or high-impurity index, and planted in a randomized block with six replications. Test 8 consisted of two selections, high index and high sugar, from population 2224 and the original parent. The two selections were, respectively, derived from sib-pollinated seed from 8 aa and 10 aa beets grown in two different isolation plots.

Variety Test I

This test was established to compare the performance of four-way restored (R_f) hybrid sugarbeets with those of several selected single-cross hybrids.

The single cross 308 X EL 32 was highest in gross sugar and tonnage at the North Farm in Logan (Table 1a). However, this variety was not significantly different from 13 other varieties as indicated by Duncan's new multiple-range test. Only one R_f hybrid, No. 37, was among the top lines for gross sugar. In general, the varieties had a similar order for root weight as they did for gross sugar. Variety No. 38, a R_f hybrid, had the highest sugar percentage and, with the exception of the single-cross variety 24, was significantly better than all others in the test. While there was a slight advantage of the single crosses for yield, no advantage was noted for sugar percentage. The two top single crosses were among the poorest in impurity indices (Table 1b). Variety No. 4, a single cross, and No. 32, a R_f hybrid, were lowest in impurity index. These varieties, along with Nos. 27, 23, 29, and 47, were lowest in amino N. Four single crosses, 2, 24, 21, and 7, were lowest in sodium content. Varieties 6, 24, 31, 45, and 21 were lowest in ppm K.

The beets at Farmington were grown under a high fertility level this year due to an error in calculation of land area at the time of fertilizer application. A single cross was again highest in gross sugar, but of the top 26 entries which were not significantly different, 12 were R_f hybrids, 12 were single crosses and two were checks, 7114 and F & M Commercial (Table 2a). The single cross No. 3, which was best in gross sugar at Logan, was 27th at Farmington, which indicates there was a significant location interaction. However, this single cross, 308 X EL 32, also had the highest tonnage at Farmington. With the exception of No. 3, the entries having high tonnage were those with high gross sugar. Variety No. 2 was highest in sugar. Nos. 4, 21, 35, and 38 were also among the better sugar entries. Six R_f

hybrids (24, 44, 45, 33, 34, 41), four single crosses (21, 2, 7, 16), and the 7114 check had the lowest impurity indices (Table 2b). R_f hybrids 33 and 39, single cross No. 2, and 7114 check were lowest in amino N. Single crosses 2, 21, 24, and 16 were lowest in Na. Entries 6, 45, 9, and 41 were best for low K content.

Data combined for the two locations shows that U & I single-cross hybrid #7 (No. 20) topped all varieties for gross sugar, but it was not significantly better than 7114 check, F & M commercial, seven R_f hybrids, or 12 other single crosses (Table 3a). Single cross No. 3, 308 X EL 32, gave significantly the highest tonnage, with the exception of the three entries 20, 12, and 14. However, this variety had the lowest sugar percent in the test, 13.4%. Summarized over the two locations, the R_f hybrid No. 38 was best for sugar percentage, followed closely by the three single crosses 2, 24, and 4. However, No. 38 was not significantly superior to 6 single crosses and 7 R_f hybrids for this characteristic.

Thirteen single crosses, 11 R_f hybrids, and two of the checks were at the lower end of the ranked means for sugar. Entries 24, 33, 16, 45, 44, 21, 7, 34, and 6 were best for low-impurity index ratings (Table 3b). The lowest value entry was only significantly better than 10 other entries. The lowest amino N values were observed for Nos. 33, 32, and 16. Nos. 2, 21, 24, and 16 were best for low Na and 6, 45, 9, 41, 7, and 24 were best for low K content. No. 43 was the poorest variety for all quality characteristics.

Compared with the test means, more R_f hybrids were below the mean in tonnage than above the mean. Fifteen of the 23 R_f hybrids were above the test mean for sucrose, and approximately the same number showed lower impurities than the respective means for impurity index, amino N, Na and K.

The single crosses had about equal numbers of lines above the means as below with the exception of the amino N variable where 2/3 of the entries had higher values than the overall mean.

In comparison with the experimental check 7114, F & M commercial, and US 22/3, both the single crosses and four-way R_f hybrids gave good performance.

The data of the two tests combined suggest that single crosses may give better yield than R_f hybrids. The restored hybrids, however, showed superior sugar percentage and index. The inbreds in these four-way hybrids were not composed of lines specifically selected for their combining ability.

Table 1a. Variety Test 1, Acre Yield and Sugar Percentage, North Farm, Logan, Utah, 1968.

Code No.	Variety Description	Acre Yield: Gross Sugar		Acre Yield: Tons Beets		Percent Sugar	
3	308 X E1 32	7,963	a*	28.26	a	14.1	n
1	308 X CT9A	7,952	a	27.03	ab	14.7	efghijklmn
20	UI Hybrid #7	7,943	ab	25.20	bcdef	15.8	bc
10	EL 33 X 9540 S	7,776	abc	25.86	abcd	15.1	bcdefghijklm
12	308 X 0198 S	7,639	abcd	26.71	abc	14.3	klmn
24	118121 MS X 512066Wy	7,543	abcde	23.78	defghij	15.9	ab
8	133 X Ov.2	7,454	abcdef	23.91	defghi	15.6	bcdef
37	(AI-1 X Ov3)X(128 X R_f)	7,398	abcdefg	23.74	defghijk	15.6	bcdef
5	Ov.1 X 712 S	7,375	abcdefgh	25.35	bcde	14.5	jklmn
18	133 X 7534	7,276	abcdefghi	24.18	cdefgh	15.1	bcdefghijklm
19	Ov.1 X 7535	7,186	abcdefghij	23.82	defghij	15.0	bcdefghijklm
9	7114 check	7,144	abcdefghijk	23.78	defghij	15.0	bcdefghijklmn
14	Ov.1 X L-36	7,130	abcdefghijk	24.27	cdefg	14.7	fghijklmn
21	11863 X CT7	7,123	abcdefghijk	23.06	defghijkl	15.4	bcdefghi
4	0156 X 0198 S	6,980	bcdefghijkl	22.36	fghijklmn	15.6	bcdef
38	(AI-1 X00.5)X(F.C.503XRf)	6,937	cdefghijkl	20.89	jklmnopq	16.6	a
46	(308 XCT5B)X(AI-1XR_f)	6,866	cdefghijkl	24.18	cdefgh	14.2	mn
43	(308 X00.5)X(CT9XR_f)	6,829	cdefghijklm	23.93	defghi	14.3	lmn
29	(CT9XC672)X(AI-1XR_f)	6,782	defghijklm	22.17	ghijklmn	15.3	bcdefghij
28	(AI-1 X0v.3)X(129XR_f)	6,770	defghijklm	21.66	ghijklmn	15.6	bcdef
48	(129XCT5 5)X(CT9XR_f)	6,732	defghijklm	22.70	efghijklm	14.8	cdefghijklmn
33	(AI-1XF.C.503)X(C515XR_f)	6,712	defghijklm	21.40	ghijklmno	15.7	bcde
26	(AI-1XEL31)X(129XR_f)	6,687	defghijklm	21.64	ghijklmn	15.5	bcdefg
47	(CT9X00.5)X(C515XR_f)	6,603	efghijklmn	21.45	ghijklmno	15.4	bcdefgh
22	106466MS X CT5A	6,540	fghijklmno	21.49	ghijklmno	15.2	bcdefghijk
42	(308XEL31)X(129XR_f)	6,520	fghijklmnop	21.51	ghijklmno	15.2	bcdefghijkl
15	133 X F.C.601	6,515	fghijklmnop	21.45	ghijklmno	15.2	bcdefghijkl
2	AI-10 X 0198S	6,482	fghijklmnop	21.11	ijklmnopq	15.3	bcdefghij
40	F&H comm'l	6,481	fghijklmnop	22.40	fghijklmn	14.4	jklmn
23	106666MS X CT5A	6,465	ghijklmnop	22.02	ghijklmn	14.7	fghijklmn
27	(308XCT5B)X(129XR_f)	6,449	ghijklmnop	22.85	efghijkl	14.1	n
11	308 X Ov.1	6,444	ghijklmnop	20.83	klmnopq	15.5	bcdefg
45	(127X133)X(AI-1XR_f)	6,431	ghijklmnop	21.06	ijklmnopq	15.3	bcdefghij
39	(308X00.5)X(128XR_f)	6,401	hijklmnopq	22.08	ghijklmn	14.5	ijklmn
49	US 22/3 check	6,393	hijklmnopq	20.66	lmnopqr	15.4	bcdefghi
13	308 X AI-10	6,346	ijklmnopq	21.06	ijklmnopq	15.1	bcdefghijklm
35	(128X00.2)X(F.C.503XR$_f$)	6,338	ijklmnopq	20.56	lmnopqr	15.4	bcdefgh
44	(AI-1X129)X(C515XR$_f$)	6,281	ijklmnopq	20.37	lmnopqr	15.3	bcdefghij
16	129 X F.C. 601	6,276	jklmnopq	20.13	lmnopqr	15.5	bcdefg
25	(308Xm') X(AI-1XR_f)	6,275	jklmnopq	21.36	ghijklmnop	14.6	ghijklmn

Table 1a. CONTINUED

Code No.	Variety Description	Acre Yield: Gross Sugar	Acre Yield: Tons Beets	Percent Sugar
31	(AI-1X128)X(C515XR$_f$)	6,250 jklmnopq	20.96 jklmnopq	14.9 bcdefghijklmn
7	129 X L-36	6,186 klmnopq	21.30 hijklmnop	14.5 hijklmn
34	(S33XCT5A)X(FC 503XR$_f$)	6,047 lmnopq	19.51 nopqr	15.5 bcdefg
17	OV.1 X 0461 S	5,862 mnopqr	19.86 mnopqr	14.7 defghijklmn
36	(CT9XEL31)X(128XR$_f$)	5,659 nopqr	18.39 qrs	15.4 bcdefghi
41	(S33XFC503)X(AI-1XR$_f$)	5,597 opqr	18.65 opqr	15.0 bcdefghijklmn
32	(S33XCT5B)X(C515XR$_f$)	5,540 pqr	17.88 rs	15.5 bcdefg
30	(129 X 032)X(C515XR$_f$)	5,436 qr	18.48 pqrs	14.7 efghijklmn
6	133 X 0461 S	5,000 r	15.97 s	15.7 bcd
Gen. Mean all Var.		6,674	22.11	15.1
S.E. of mean		403.74	1.19	.38
C.V. %		12.10	10.80	4.99
Calculated F		5.47	8.16	3.82

* Duncan's new multiple range test. Means having the same suffix letter are not significantly different at 5% point.

Table 1b. Variety Test I, Impurity Index, Amino N, Na and K, North Farm, Logan, Utah, 1968.

Code No.	Impurity Index	PPM Amino N	PPM Na	PPM K
3	626 b*	315 1/	415 a	1,674 ab
1	571 bc	287	381 ab	1,670 ab
20	446 cdef	269	257 fghijklmnop	1,362 efghijklm
10	548 bcdef	248	369 bc	1,773 a
12	637 ab	328	338 bcd	1,845 a
24	417 cdef	308	176 tu	1,166 mn
8	475 bcdef	271	281 efgh	1,486 bcdefgh
37	470 cdef	298	211 mnopqrst	1,412 cdefghijkl
5	550 bcde	262	258 fghijklmno	1,761 a
18	485 bcdef	276	292 defg	1,390 efghijklm
19	532 bcdef	305	237 ghijklmnopqr	1,640 abc
9	440 cdef	268	240 ghijklmnopqr	1,232 jklmn
14	519 bcdef	290	274 fghij	1,488 bcdefgh
21	428 cdef	285	182 stu	1,228 klmn
4	393 f	208	207 opqrst	1,327 fghijklm
38	410 def	231	201 qrst	1,502 bcdefg
46	503 bcdef	251	270 fghijk	1,472 bcdefghi
43	527 bcdef	226	327 cde	1,626 abcd
29	406 def	198	241 ghijklmnopqr	1,350 efghijklm
28	440 cdef	274	217 lmnopqrst	1,339 fghijklm
48	462 cdef	234	215 lmnopqrst	1,498 bcdefg
33	406 def	210	204 pqrst	1,399 defghijkl
26	420 cdef	254	229 hijklmnopqrst	1,261 hijklmn
47	489 bcdef	204	327 cde	1,727 a
22	473 bcdef	299	228 hijklmnopqrst	1,358 efghijklm
42	494 bcdef	261	257 fghijklmnop	1,557 abcdef
15	431 cdef	241	260 fghijklmno	1,287 ghijklmn
2	436 cdef	280	149 u	1,284 ghijklmn
40	534 bcdef	309	352 abc	1,340 fghijklm
23	432 cdef	198	268 fghijkl	1,358 efghijklm
27	492 bcdef	195	266 efg	1,576 abcde
11	507 bcdef	337	249 hijklmnopqrs	1,463 bcdefghij
45	420 cdef	236	278 efgh	1,230 klmn
39	512 bcdef	269	290 defg	1,469 bcdefghi
49	490 bcdef	286	263 fghijklm	1,491 bcdefgh

Table 1b. CONTINUED

Code No.	Impurity Index	PPM Amino N	PPM Na	PPM K
13	508 bcdef	323	255 fghijklmnopq	1,411 cdefghijkl
35	462 cdef	291	222 ijklmnopqrst	1,373 efghijklmn
44	424 cdef	210	218 klmnopqrst	1,419 cdefghijkl
16	408 cdef	212	209 nopqrstu	1,399 defghijkl
25	499 bcdef	246	303 def	1,475 bcdefghi
31	426 cdef	241	261 fghijklmn	1,199 lmn
7	413 def	217	188 rstu	1,244 ijklmn
34	412 def	228	244 ghijklmnopq	1,297 ghijklmn
17	552 bcd	367	230 hijklmnopqrs	1,449 bcdefghijk
36	416 cdef	211	285 efg	1,302 ghijklmn
41	453 cdef	285	219 klmnopqrst	1,260 hijklmn
32	393 f	197	251 fghijklmnopq	1,286 ghijklmn
30	472 bcdef	218	276 efghi	1,508 bcdefg
6	394 ef	267	221 jklmnopqrst	1,086 n
Gen. Mean of all Var.	476	268	257	1,421
S.E. of Mean	62.83	92.53	21.81	94.46
C.V. %	26.42		16.97	13.29
Calculated F	3.47	1.62	12.36	6.01

* Duncan's new multiple range test. Means having the same suffix letter are not significantly different at 5% point.

1/ The Duncan's test for amino N was incorrect due to a punch card error so it was omitted from this table. Insufficient time is available to re-program and get this data by the due date of the report.

Table 2a. Variety Test 1, Acre Yield and Sugar Percentage, Farmington, Utah, 1968.

Code No.	Variety Description	Acre Yield Gross Sugar		Acre Yield Tons Beets		Percent Sugar	
24	118121MS X 512066Wy	11,474	a*	36.89	abcdefghij	15.6	bcde
20	UI Hybrid #7	11,323	ab	38.92	ab	14.6	ijklmn
37	(AI-1XOV.3)X(128XR$_f$)	11,313	abc	37.52	abcdefg	15.1	bcdefghijk
12	308 X 0198 S	11,245	abcd	38.82	ab	14.5	klmn
9	7114 check	11,210	abcd	37.96	abcde	14.8	hijkl
22	106466MS X CT5A	11,085	abcde	37.56	abcdef	14.8	fghijkl
42	(308XEL31)X(129XR$_f$)	10,964	abcdef	38.04	abcd	14.5	klmn
47	(CT9X00.5)X(C515XR$_f$)	10,909	abcdefg	37.30	abcdefg	14.6	ijklmn
2	AI-10 X 0198 S	10,863	abcdefgh	32.68	klmnopq	16.6	a
27	(308XCT5B)X(129XR$_f$)	10,860	abcdefgh	37.90	abcde	14.3	lmnop
23	106666MS X CT5A	10,857	abcdefgh	37.18	abcdefgh	14.7	hijklm
18	133 X 7534	10,816	abcdefgh	38.52	abc	14.0	mnopq
4	0156 X 0198 S	10,798	abcdefghi	34.33	defghijklmno	15.8	b
40	F & M comm'l	10,696	abcdefghij	37.08	abcdefghi	14.4	klmn
44	(AI-1X129)X(C515XR$_f$)	10,629	abcdefghij	34.75	cdefghijklmno	15.3	bcdefghi
14	OV.1 X L-36	10,627	abcdefghij	39.00	ab	13.7	pqr
10	EL33 X 9540 S	10,621	abcdefghij	36.47	bcdefghijkl	14.6	jklmn
32	(S33XCT5B)X(C515XR$_f$)	10,606	abcdefghij	34.79	cdefghijklmno	15.2	bcdefghij
39	(308 X00.5)X(128X R$_f$)	10,598	abcdefghij	36.29	bcdefghijkl	14.6	ijklmn
28	(AI-1XOV.3)X(129XR$_f$)	10,562	abcdefghijk	34.09	efghijklmno	15.5	bcdef
45	(127 X133)X(AI-1XR$_f$)	10,549	abcdefghijkl	35.25	bcdefghijklm	14.9	defghijkl
35	(128X00.2)X(F.C.503XR$_f$)	10,521	abcdefghijkl	33.67	ghijklmnop	15.6	bcd
25	(308Xm')X(AI-1XR$_f$)	10,493	abcdefghijkl	36.56	bcdefghijk	14.4	lmno
13	308 X AI-10	10,453	abcdefghijkl	35.21	bcdefghijklmn	14.8	fghijkl
46	(308XCT5B)X(AI-1XR$_f$)	10,313	abcdefghijklm	37.08	abcdefghi	13.9	nopq
6	133 X 0461 S	10,297	abcdefghijklm	33.18	ijklmnopq	15.5	bcdefg
3	308 X EL 32	10,257	bcdefghijklm	40.67	a	12.6	r
19	OV.1 X 7535	10,255	bcdefghijklm	35.15	bcdefghijklmn	14.7	hijklm
29	(CT9XC672)X(AI-1XR$_f$)	10,142	bcdefghijklmn	34.39	defghijklmno	14.8	hijkl
30	(129X032)X(C515XR$_f$)	10,104	cdefghijklmno	33.73	fghijklmnop	15.0	cdefghijkl
33	(AI-1XF.C.503)X(C515XR$_f$)	10,086	cdefghijklmno	33.81	fghijklmno	14.9	defghijkl
34	(S33XCT5A)X(F.C.503XR$_f$)	10,067	defghijklmno	33.00	jklmnopq	15.2	bcdefghij
7	129 X L-36	9,994	defghijklmno	33.46	ghijklmnop	14.9	defghijkl
43	(308X00.5)X(CT9XR$_f$)	9,928	efghijklmno	36.59	bcdefghijk	13.6	q
26	(AI-1XE131)X(129XR$_f$)	9,792	fghijklmnop	32.18	mnopqr	15.2	bcdefghij
21	11863 X CT 7	9,725	fghijklmnop	31.12	opqrs	15.7	bc
5	OV.1 X 712 S	9,709	ghijklmnop	35.37	bcdefghijklm	13.8	opq
38	(AI-1X00.5)X(F.C.503XR$_f$)	9,664	hijklmnop	30.94	opqrs	15.6	bcd
41	(S33XF.C.503)X(AI-1XR$_f$)	9,602	ijklmnop	32.50	lmnopqr	14.8	ghijkl
48	(129XCT5S)X(CT9XR$_f$)	9,550	ijklmnop	32.56	lmnopqr	14.7	hijklm

Table 2a. CONTINUED

Code No.	Variety Description	Acre Yield: Gross Sugar	Acre Yield: Tons Beets	Percent Sugar
36	(CT9XEL31)X(129XR_f)	9,517 jklmnop	33.25 hijklmnopq	14.4 lmno
49	US 22/3	9,367 klmnop	31.66 mnopqr	14.8 fghijkl
8	133 X OV.2	9,346 lmnop	32.14 mnopqr	14.6 ijklmn
31	(AI-1X128)X(C515XR_f)	9,212 mnopq	31.26 nopqr	14.7 hijklm
16	129 X F.C. 601	9,037 nopq	29.47 qrs	15.4 bcdefgh
17	OV.1 X 0461 S	8,969 nopq	29.95 pqrs	15.0 defghijkl
1	308 X CT9A	8,921 opq	32.86 klmnopq	13.6 qr
11	308 X OV.1	8,631 pq	28.93 rs	14.9 efghijkl
15	133 X F.C. 601	8,154 q	27.59 s	14.8 hijklm
Gen. Mean of all Var.		10,219	34.69	14.77
S.E. of Mean		492.71	1.58	.30
C.V. %		9.64	9.09	4.02
Calculated F		4.75	7.02	10.33

* Duncan's new multiple range test. Means having the same suffix letter are not significantly different at 5% point.

Table 2b. Variety Test I, Impurity Index, Amino N, Na, and K, Farmington, Utah, 1968.

Code No.	Impurity Index	PPM Amino N	PPM Na	PPM K
24	484 n*	264 bcdefghij	363 qrs	1,425 jklmno
20	680 defghij	331 abcdefg	715 cdefgh	1,599 fghijklmn
37	562 fghijklmn	284 abcdefghij	483 klmnopqr	1,563 ghijklmno
12	823 abcd	325 abcdefgh	791 bcd	2,303 a
9	504 lmn	211 ij	565 fghijklmnopq	1,332 mno
22	601 efghijklmn	284 abcdefghij	548 fghijklmnopq	1,629 efghijklmn
42	691 defghi	319 abcdefghi	654 cdefghijklmn	1,757 cdefgh
47	652 efghijkl	263 bcdefghij	618 defghijklmno	1,862 cdefg
2	516 lmn	352 abcd	271 s	1598 fghijklmn
27	649 efghijklm	236 fghij	716 cdefgh	1,753 cdefghi
23	562 fghijklmn	230 ghij	601 defghijklmno	1,490 hijklmno
18	678 defghijk	300 abcdefghij	785 bcde	1,442 ijklmno
4	567 fghijklmn	314 abcdefghi	457 lmnopqrs	1,639 efghijklm
40	688 defghi	352 abcd	728 cdef	1,524 hijklmno
44	510 lmn	241 fghij	461 lmnopqrs	1,497 hijklmno
14	742 bcde	335 abcdefg	690 cdefghij	1733 cdefghij
10	710 cdefg	279 abcdefghij	719 cdefg	1,977 bcd
32	549 ghijklmn	216 hij	548 fghijklmnopq	1,647 efghijkl
39	713 cdef	312 abcdefghi	631 defghijklmno	1,992 bc
28	538 ijklmn	269 abcdefghij	521 ghijklmnopq	1,511 hijklmno
45	506 lmn	230 ghij	558 fghijklmnopq	1,293 no
35	517 klmn	295 abcdefghij	444 opqrs	1419 klmno
25	625 efghijklmn	282 abcdefghij	676 cdefghijk	1,514 hijklmno
13	622 efghijklmn	325 abcdefgh	523 ghijklmnopq	1,632 efghijklm
46	703 cdefgh	345 abcdef	662 cdefghijkl	1,564 ghijklmno
6	521 jklmn	294 abcdefghij	557 fghijklmnopq	1,257 o
3	881 ab	275 abcdefghij	912 ab	1,992 bc
19	750 bcde	377 a	595 defghijklmno	2,018 bc
29	561 fghijklmn	230 ghij	582 efghijklmnop	1,533 hijklmno
30	552 fghijklmn	250 defghij	602 defghijklmno	1,465 hijklmno
33	496 lmn	197 j	465 lmnopqrs	1,492 hijklmno
34	515 lmn	236 fghij	512 hijklmnopq	1,470 hijklmno
7	504 lmn	242 efghij	454 mnopqrs	1,385 klmno
43	929 a	367 ab	1,059 a	2,189 ab
26	542 hijklmn	274 abcdefghij	497 ijklmnopq	1,489 hijklmno

Table 2b. CONTINUED

Code No.	Impurity Index	PPM Amino N	PPM Na	PPM K
21	487 mn	290 abcdefghij	289 rs	1,467 hijklmno
5	844 abc	351 abcde	842 bc	1,928 bcde
38	571 fghijklmn	291 abcdefghij	451 nopqrs	1,750 cdefghi
41	489 lmn	236 fghij	422 opqrs	1,342 lmno
48	557 fghijklmn	215 hij	487 jklmnopqr	1,683 defghijk
36	559 fghijklmn	219 hij	583 efghijklmno	1,480 hijklmno
49	651 efghijkl	280 abcdefghij	658 cdefghijklm	1,778 cdefgh
8	637 efghijklmn	278 abcdefghij	699 cdefghi	1,596 fghijklmn
31	569 fghijklmn	263 bcdefghij	513 hijklmnopq	1,557 ghijklmno
16	508 lmn	218 hij	379 pqrs	1,627 efghijklm
17	646 efghijklmn	365 ab	597 defghijklmno	1,576 fghijklmn
1	813 abcd	362 abc	720 cdefg	1,877 cdef
11	605 efghijklmn	310 abcdefghi	481 klmnopqr	1,673 efghijk
15	555 fghijklmn	255 cdefghij	537 fghijklmnopq	1,469 hijklmno
Gen. Mean of all Var.	615	283	584	1,628
S.E. of Mean	65.78	44.39	83.31	126.78
C.V. %	21.40	31.38	28.53	15.57
Calculated F	5.73	2.37	6.56	6.39

* Duncan's new multiple range test. Means having the same suffix letter are not significantly different at 5% point.

Table 3a. Variety Test 1, Acre Yield and Sugar Percentage, Combined Locations, 1968.

Code No.	Variety Description	Acre Yield: Gross Sugar		Acre Yield: Tons Beets		Percent Sugar	
20	UI Hybrid #7	9,633	a*	32.06	abc	15.2	bcdefghij
24	118121MS X 512066Wy	9,508	ab	30.34	bcdefghi	15.7	abc
12	308 X 0198	9,442	abc	32.76	ab	14.4	jklmnop
37	(AI-1X0V.3)X(128XR$_f$)	9,355	abcd	30.63	bcdefgh	15.3	abcdefgh
10	EL 33 X 9540 S	9,198	abcde	31.17	bcdef	14.8	efghijklmno
9	7114 check	9,177	abcdef	30.87	bcdefg	14.9	cdefghijklmn
3	308 X EL 32	9,110	abcdefg	34.46	a	13.4	p
18	133 X 7534	9,046	abcdefg	31.35	bcde	14.6	hijklmnop
4	0156 X 0198 S	8,889	abcdefgh	28.34	cdefghijklmno	15.7	abcd
14	0V.1 X L-36	8,878	abcdefghi	31.63	abcd	14.2	lmnop
22	106466MS X CT5A	8,813	abcdefghij	29.52	bcdefghijklm	15.0	cdefghijkl
47	(CT9 X 00.5)X(C515XR$_f$)	8,756	abcdefghijk	29.37	bcdefghijklm	15.0	cdefghijk
42	(308XEL31)X(129XR$_f$)	8,742	abcdefghijk	29.78	bcdefghij	14.8	efghijklmno
19	0v.1 X 7535	8,721	abcdefghijk	29.48	bcdefghijklm	14.8	defghijklmno
2	AI-10 X 0198 S	8,673	abcdefghijkl	26.89	jklmnopqrs	16.0	ab
28	(AI-1 X0v.3)X(129XR$_f$)	8,666	abcdefghijkl	27.87	fghijklmnopqrs	15.6	abcdef
23	106666MS X CT5A	8,661	abcdefghijkl	29.60	bcdefghijkl	14.7	ghijklmnop
27	(308 XCT5B)X(129XR$_f$)	8,655	abcdefghijkl	30.37	bcdefghi	14.2	klmnop
46	(308XCT5B)X(AI-1XR$_f$)	8,589	abcdefghijklm	30.63	bcdefgh	14.1	op
40	F & M Comm'l	8,588	abcdefghijklm	29.74	bcdefghijk	14.4	jklmnop
5	0v.1 X 712 S	8,542	abcdefghijklm	30.36	bcdefghi	14.1	nop
39	(308X00.5)X(128XR$_f$)	8,499	abcdefghijklmn	29.19	cdefghijklmn	14.5	hijklmnop
45	(127X133)X(AI-1XR$_f$)	8,490	bcdefghijklmn	28.16	defghijklmnopq	15.1	cdefghij
29	(CT9XC672)X(AI-1XR$_f$)	8,462	bcdefghijklmn	28.28	defghijklmnop	15.0	cdefghijk
44	(AI-1X129)X(C515XR$_f$)	8,455	bcdefghijklmn	27.56	ghijklmnopqrs	15.3	abcdefghi
1	308 X CT9A	8,436	bcdefghijklmno	29.94	bcdefghij	14.2	mnop
35	(128X00.2)X(F.C.503XR$_f$)	8,430	bcdefghijklmno	27.11	ijklmnopqrs	15.5	abcdefg
21	11863 X CT 7	8,424	bcdefghijklmno	27.09	ijklmnopqrs	15.6	abcdef
8	133 X 0v.2	8,400	bcdefghijklmno	28.02	efghijklmnopqr	15.1	cdefghij
13	308 X AI-10	8,399	bcdefghijklmno	28.14	efghijklmnopq	15.0	cdefghiklmn
33	(AI-1XF.C.503)X(C515XR$_f$)	8,399	bcdefghijklmno	27.60	ghijklmnopqrs	15.3	bcdefghi
25	(308Xm')X(AI-1XR$_f$)	8,384	cdefghijklmno	28.96	cdefghijklmno	14.5	ijklmnop
43	(308X00.5)X(CT9XR$_f$)	8,378	cdefghijklmno	30.26	bcdefghij	13.9	p
38	(AI-1X00.5)X(F.C.503XR$_f$)	8,300	defghijklmno	25.92	nopqrs	16.1	a
26	(AI-1XEL31)X(129XR$_f$)	8,240	efghijklmno	26.91	ijklmnopqrs	15.4	abcdefgh
48	(129XCT5S)X(CT9XR$_f$)	8,141	efghijklmno	27.63	ghijklmnopqrs	14.8	efghijklmnop
7	129 X L-36	8,090	efghijklmno	27.38	hijklmnopqrs	14.7	fghijklmnop
32	(S33XCT5B)X(C515XR$_f$)	8,073	fghijklmno	26.34	klmnopqrs	15.4	abcdefgh
34	(S33XCT5A)X(F.C.503XR$_f$)	8,057	ghijklmno	26.26	lmnopqrs	15.4	abcdefgh
31	US 22/3	7,880	hijklmno	26.16	mnopqrs	15.1	cdefghij

Table 3a. CONTINUED

Code No.	Variety Description	Acre Yield Gross Sugar	Acre Yield Tons Beets	Percent Sugar
30	(129X032)X(C515XR_f)	7,770 ijklmno	26.10 mnopqrs	14.9 cdefghijklmn
31	(AI-1X128)X(C515XR_f)	7,731 jklmno	26.11 mnopqrs	14.8 defghijklmno
16	129 X F.C. 601	7,656 klmno	24.80 qrs	15.5 abcdefg
6	133 X 0461 S	7,649 klmno	24.58 rs	15.6 abcde
41	(S33XF.C.503)X(AI-1XR_f)	7,600 lmno	25.58 opqrs	14.9 cdefghijklmn
36	(CT9XEL31)X(128XR_f)	7,588 lmno	25.82 nopqr	14.9 cdefghijklmn
11	308 X Ov.1	7,538 mno	24.88 pqrs	15.2 bcdefghij
17	Ov.1 X 0461 S	7,415 no	24.90 pqrs	14.9 defghijklmno
15	133 X F.C. 601	7,334 o	24.52 s	15.0 cdefghijklm
Gen. Mean all Var.		8,446	28.40	14.94
S.E. of Mean		318.50	.99	.24
C.V. %		10.67	9.85	4.54
Calculated F		6.16	11.20	10.44

* Duncan's new multiple range test. Means having the same suffix letter are not significantly different at the 5% point.

Table 3b. Variety Test I, Impurity Index, Amino N, Na and K, Combined Locations, 1968.

Code No.	Impurity Index	PPM Amino N	PPM Na	PPM K
20	563 defghij*	300 1/	486 cdefghi	2,074 a
24	450 j	286	270 nop	1,295 lmno
12	730 a	327	565 abc	2,024 a
37	516 efghij	291	347 hijklmnop	1,488 hijklmn
10	629 bcdefgh	264	544 bcde	1,875 abc
9	472 ghij	239	402 defghijklmn	1,282 mno
3	754 ab	295	663 ab	1,833 abcde
18	581 cdefghij	288	539 bcdef	1,416 ijklmno
4	480 ghij	261	332 jklmnop	1,483 hijklmn
14	630 bcdefg	312	482 cdefghij	1,610 cdefghijk
22	537 efghij	291	388 ghijklmn	1,493 hijklmn
47	570 defghij	234	472 cdefghijk	1,794 abcdef
42	592 cdefghij	290	455 cdefghijkl	1,657 bcdefghi
19	641 bcdef	341	416 cdefghijklmn	1,829 abcde
2	476 ghij	316	210 p	1,441 ijklmno
28	489 efghij	272	369 ghijklmno	1,425 ijklmno
23	497 efghij	214	435 cdefghijklm	1,424 ijklmno
27	570 defghij	216	502 cdefg	1,664 bcdefgh
46	603 cdefghij	298	466 cdefghijkl	1,518 ghijklmn
40	611 bcdefghi	331	540 bcde	1,432 ijklmno
5	697 bcd	306	550 bcd	1,844 abcd
39	612 bcdefghi	291	461 cdefghijkl	1,731 bcdefgh
45	463 ij	233	418 cdefghijklmn	1,261 no
29	483 efghij	214	411 defghijklmn	1,441 ijklmno
44	467 ij	225	339 ijklmnop	1,458 hijklmn
1	692 bcde	324	550 bcd	1,774 abcdefg
35	490 efghij	293	333 jklmnop	1,396 ijklmno
21	457 ij	287	235 op	1,347 klmno
8	556 defghij	275	490 cdefgh	1,541 fghijklm
13	565 defghij	324	389 fghijklmn	1,521 ghijklmn
33	451 j	203	334 jklmnop	1,446 ijklmno
25	563 defghij	264	490 cdefgh	1,494 hijklmn
43	728 bc	296	693 a	1,908 ab
38	490 efghij	261	326 klmnop	1,626 cdefghij
26	481 ghij	264	363 ghijklmno	1,375 jklmno

Table 3b. CONTINUED

Code No.	Impurity Index	PPM Amino N	PPM Mg	PPM K
48	509 efghij	224	351 hijklmnop	1,590 defghijk
7	458 ij	229	321 lmnop	1,314 lmno
32	471 hij	206	399 efghijklmn	1,467 hijklmn
34	463 ij	232	378 ghijklmno	1,383 ijklmno
49	570 defghij	283	461 cdefghijkl	1,634 cdefghij
30	512 efghij	234	439 cdefghijklm	1,487 hijklmn
31	498 efghij	252	387 ghijklmn	1,378 jklmno
16	450 j	204	294 mnop	1513 ghijklmn
6	458 ij	281	389 fghijklmn	1,172 o
41	471 ghij	260	320 lmnop	1,301 lmno
36	487 efghij	215	434 cdefghijklm	1,391 ijklmno
11	556 defghij	323	355 ghijklmnop	1,568 efghijkl
17	599 cdefghij	366	413 cdefghijklmn	1,512 ghijklmn
15	493 efghij	248	399 efghijklmn	1,378 jklmno
Gen. Mean of all Var.	545	275	421	1525
S.E. of Mean	45.49	51.31	43.06	79.05
C.V. %	23.60		28.96	14.66
Calculated F	7.93	2.38	10.54	11.25

* Duncan's new multiple range test. Means having the same suffix letter are not significantly different at 5% point.

1/ The Duncan's test for amino N was incorrect due to a punch card error so it was omitted from this table. Insufficient time is available to re-program and get this data by the due date of the report.

Variety Test 2

The lines included in this yield trial consisted of experimental inbreds in S_2 to S_5 generations which have been selected previously for curly-top resistance, type O character, or sugar percentage. Certain inbreds, CT5, NB-1, F.C. 501 and L-13, were included in this test at Logan for comparison.

The inbred yielding the highest gross sugar, 721, is an S_5 inbred selected from [(Ovana X US 22/3) X US 22/3] X CT 8 (Table 4a). It was second highest in tonnage and had a high sugar percentage. It was not significantly better in tonnage or gross sugar than four other entries. Inbred 6520 had the highest sugar percentage but was one of the lowest yielding varieties. This line is a sister selection to 721 and also to the L-53 line released in 1966. Other high-sugar lines were: 735, an S_3 selection from SLC 130 that carries extremely high curly-top resistance; 710, an S_3 selection with CT 9A parentage; and 7535, an S_3 inbred selected from CT 5 X .002, a nematode resistant selection received from American Crystal Sugar Co. in 1960. Inbred 7533 of C019 had the lowest sugar percentage in the test. This variety was also highest in impurity factors (Table 4b). Line 6520 had the lowest impurity index value and was extremely low in ppm Na. Other inbreds having high quality, as determined by the impurity index, were 721, CT5, and 756.

Variety Test 3

With the exception of two check varieties, 7114 (a Logan experimental three-way hybrid) and US 22/3, all of the entries in this test were recently made single crosses. The test was grown at Farmington, Utah.

SLC 133 X 712 sugar selection gave the highest gross sugar, second highest tonnage, and had a good sugar percentage (Table 5). SLC 133 also combined well with C 019 and CT5 (codes 18 and 7) for yield. Lines 22 and 23, which yielded high in gross sugar, are Utah-Idaho Sugar Co. inbreds that have shown excellent performance in their variety trials. Single cross No. 6 had the highest sugar percentage (16.3%) and was lowest in impurity index and Na. Other lines having high sugar percentage were 3, 14, 12, and 2. Three of these lines had SLC 129 as a common parent and the fourth had SLC 128, a progenitor of SLC 129, as the female progenitor. L-36 tended to contribute to high sugar also, while C 019 gave low sugar percentage in every cross. Of interest in this test was the observation that the high-sugar lines 14, 6, 12, 1, 3, and 2 had the lowest impurity indices.

Table 4a. Variety Test 11, Inbred Acre Yield and Sugar Percentage, North Farm, 1968.

Code No.	Inbred	Acre Yield: Gross Sugar	Acre Yield: Tons Beets	Percent Sugar	Beet Count
11	721	7,037 a*	22.19 ab	15.8 abcd	59
10	710	6,649 ab	20.92 abc	15.9 abc	67
16	7533	6,339 abc	23.51 a	13.5 k	62
21	7538	6,271 abc	21.68 ab	14.5 hij	60
8	CT 5	6,085 bcd	20.03 bc	15.2 bcdefg	70
9	CT5B	5,830 bcd	19.48 bcd	15.0 fgh	72
18	7535	5,818 bcd	18.16 cdef	16.0 ab	72
7	NB-1	5,619 cde	18.03 cdef	15.6 bcde	69
19	7536	5,570 cdef	15.58 cde	15.0 defgh	69
20	7537	5,562 cdef	18.12 cdef	15.4 bcdefg	70
6	6522	5,423 cdefg	19.81 bc	13.7 jkl	56
14	756	5,275 defg	17.95 cdef	14.7 fghi	63
4	648	4,781 efgh	16.08 defg	14.9 efgh	56
23	7541	4,728 efgh	15.32 fgh	15.4 bcdefg	53
1	611	4,648 fghi	15.99 efg	14.5 hij	65
12	735	4,531 ghi	14.21 ghi	15.9 abc	74
17	7534	3,998 hij	13.87 ghi	14.4 hij	65
15	7529	3,882 hij	12.56 hi	15.4 bcdef	60
5	6520	3,861 hij	11.71 i	16.5 a	58
3	616	3,743 ij	12.35 hi	15.1 cdefgh	56
24	F.C. 601	3,583 j	12.48 hi	14.4 hij	53
2	L-13	3,580 j	12.05 i	14.9 cdefgh	46
13	754	3,537 j	12.77 hi	13.9 ijk	68
22	7539	3,072 j	10.56 i	14.5 hij	66
Gen. Mean all Var.		4,976	16.60	15.0	
S.E. of Mean		410.62	1.31	.38	
C.V. %		11.67	11.16	3.54	
Calculated F		15.24**	16.67**	8.39**	

* Duncan's new multiple range test. Means having the same suffix letter are not significantly different at the 5% point.

Table 4b. Variety Test II, Inbred Impurity Index, Amino N, Na and K, North Farm, 1968.

Code No.	Impurity Index	PPM Amino N	PPM Na	PPM K
11	455 jk	247 g	159 fghi	1,667 def
10	540 efghij	388 abcdef	230 cde	1,557 efg
16	942 a	440 a	374 ab	2,763 a
21	710 bc	392 abcde	351 b	2,028 bc
8	472 ijk	303 defg	153 fghi	1,435 fgh
9	545 efghij	315 bcdefg	247 cd	1,642 ef
18	492 ghijk	318 bcdefg	128 ghi	1,705 de
7	571 efghi	347 abcdefg	198 defg	1,890 cd
19	595 defg	415 abc	142 ghi	1,702 de
20	505 ghijk	278 fg	169 efghi	1,748 de
6	737 b	320 bcdefg	418 a	2,157 b
14	475 hijk	290 efg	217 def	1,309 hi
4	632 cdef	341 abcdefg	355 ab	1,894 cd
23	576 efghi	351 abcdefg	162 efghi	1,914 cd
1	682 bcd	425 ab	369 ab	1,731 de
12	531 efghijk	398 abcde	116 hi	1,611 ef
17	636 cde	400 abcde	222 def	1,744 de
15	499 ghijk	323 bcdefg	158 fghi	1,556 efg
5	425 k	334 abcdefg	100 i	1,331 ghi
3	529 fghijk	313 cdefg	175 efgh	1,693 de
24	582 efgh	334 abcdefg	198 defg	1,725 de
2	544 efghij	302 defg	291 c	1,621 ef
13	512 ghijk	290 efg	197 defg	1,374 gh
22	516 ghijk	404 abcd	168 efghi	1,135 i
Gen. Mean of all Var.	571	344	221	1,705
S.E. of Mean	44.98	45.35	29.82	102.46
C.V. %	11.14	18.63	19.12	8.50
Calculated F	12.34 **	2.60**	18.62 **	20.01 **

Table 5. Variety Test 3, Farmington, Utah, 1968.

Code No.	Variety	Acre Yield		Sugar Percent	Impurity Index	PPM		
		Gross Sugar	Tons Beets			Amino N	Na	K
15	SLC 133 X 712 S	12,040	39.36	15.3	683	366	612	1,835
23	1066466 MS X CT5A	11,880	39.81	14.9	650	321	553	1,745
22	UI Hybrid #7	11,374	37.60	15.2	620	351	528	1,612
18	SLC 133 X C019	11,204	38.87	14.4	882	527	733	2,184
7	SLC 133 X CT5	11,187	36.33	15.4	556	315	536	1,424
8	Ov.1 X CT5	11,080	38.87	14.4	755	341	749	1,832
9	(CT9 X Ov.3) X 0198	10,975	35.72	15.3	613	274	618	1,806
14	SLC 129 X 7535	10,893	34.35	15.9	550	303	321	1,816
11	SLC 129 X 7534	10,884	35.63	15 3	571	307	462	1,590
5	SLC 128 X NB-1	10,740	36.14	14.9	568	293	530	1,405
21	C515 X Ov.2	10,674	35.14	15.3	590	339	504	1,535
20	C515 X 0198	10,658	36.06	14.8	816	504	605	1,885
6	S33 X CT9A	10,631	32.66	16.3	441	258	311	1,427
4	Ov.1 X NB-1	10,624	37.12	14.4	714	317	745	1,750
12	SLC 129 X 7536	10,467	33.61	15.6	546	317	346	1,626
16	SLC 129 X C019	10,255	38.31	13.4	897	351	744	2,270
13	SLC 133 X 7536	10,154	33.79	15.0	717	418	596	1,795
25	7114 check	10,078	33.65	15.1	580	279	563	1,529
17	AI-1 X C019	9,882	35.28	14.1	852	401	706	2,123
24	US 22/3	9,601	31.88	15.0	760	376	653	2,156
10	Ov.1 X CT5B	9,282	32.53	14.2	747	336	756	1,866
1	F.C. 601 X L-36	8,979	29.21	15.4	489	229	370	1,559
3	SLC 129 X SLC 130CTR	8,856	27.72	16.0	536	312	364	1,613
19	Ov.1 X C019	8,448	31.21	13.6	910	588	752	2,276
2	SLC 128 X L-36	6,045	19.37	15.5	508	247	386	1,664
Gen. Mean all Var.		10,276	34.41	15.0	662	338	562	1,773
S.E. Mean		443.60	1.43	0.22	43.36	28.81	43.23	99.12
C.V. %		10.33	10.22	3.63	16.04	22.52	18.85	13.70
Calculated F		8.40**	9.37**	10.06**	9.87**	5.12**	11.88**	6.91**
L.S.D. (5% point)		1,226.22	4.06	0.63	122.62	81.47	122.25	280.30

Variety Test 4

Test 4 was made up of 121 varieties--inbreds, single crosses, three-way and four-way hybrids--which were grown at the North Farm at Logan, Utah, in 1968. In this screening test we hoped to obtain as much information as possible regarding combining ability of the parental material.

Acre yield in gross sugar varied from 9,290 to 6,386 pounds per acre while tons per acre varied from 30.62 to 20.71 (Table 6). In gross sugar there were no significant differences among the first 55 means when ranked in descending order. Thirty of the 55 means had some degree of Ovana material in their progenitors. Variety tests of previous years have also shown that Ovana adds to yield in tons per acre in many combinations. The highest gross sugar was produced by the single cross (129 X Ov 3) code 110. This hybrid was significantly higher than U & I Hybrid #7, 7114 check, U & I commercial, and US 22/3. The above was also true for hybrids (NB-1 X EL 32) X Ov 2 (code 56) and 128 CMS X NB-1 (code 36).

Code 110, which produced the highest gross sugar, placed fifteenth in sugar percent and was high in impurity index (541) and amino N (387).

Yields of gross sugar and tons per acre for the entries were closely associated. The single cross 1114 X 9358 was significantly higher in sugar percentage than all but five varieties in the test. This hybrid was not only highest in sugar, but also had the lowest impurity index value of all entries. Of interest was the fact that 9358 is the parent line of L-19, a high-sugar inbred which was released to the industry in 1967. Nos. 72, 49, and 47 that had high sugar percentage also had L-19 as a parent. No. 41 was not significantly better, however, than five other entries (75, 42, 72, 49, 43).

The ten top entries for sugar percentage were significantly better than all four of the checks.

Ten of the entries having lowest amino N were represented in the fifteen entries with lowest impurity index values.

Variety Test 5

Test 5 was made up of selections from population 2224. It consisted of seven low-impurity index progenies, eight high-impurity index progenies, and the original 2224 parent from which the selections were made.

The parent population gave the greatest yield in gross sugar and was significantly better than all selections except high-index code 11. (Table 7). The latter selection was superior to all entries for tonnage.

TABLE 6 VARIETY SCREENING TEST 4 121 VARIETIES(6REPS) LOGAN UTAH 1968

		ACRE YIELD GROSS SUGAR	TONS BEETS	PERCENT SUGAR	INDEX	AMINO N	PPM NA	K
110	129XOV3	9290	29.51	15.71	541	387	244	1496
56	(NB-1XE132)XOV2	9150	28.92	15.80	480	279	186	1635
36	)128CMS)XNB-1	9113	30.17	15.19	477	301	238	1356
49	(128XL-19)X(CT5X00.2)	9102	28.06	16.18	464	301	146	1574
43	(EL33X9450)XCT9A	9065	28.36	15.97	443	255	245	1447
112	NB-1XOV1	9012	29.14	15.46	500	307	237	1537
42	(EL31X030)XCT9A	9003	27.78	16.23	458	287	262	1444
64	(NB-1XEL32)X(CT5X00.2)	8993	29.34	15.33	580	371	194	1751
24	(NB1XOV1)X712S	8965	28.91	15.50	535	325	187	1716
76	(NB-1XOV3)X(CT5X00.2)	8866	28.32	15.62	568	402	214	1634
41	1114CMSX9358	8860	26.76	16.51	396	206	218	1476
11	CT9XOV3 X(9450)	8853	29.03	15.27	542	317	256	1656
45	(S33XOV2)XCT9A	8853	28.14	15.70	432	240	244	1403
50	(A1-10)X0461)X(CT5X00.2)	8824	29.35	15.04	583	326	308	1773
18	NB-1XOV1XKLIEN E	8792	28.90	15.18	571	299	231	1937
74	(133X0198)X(126X631)	8715	28.44	15.30	605	347	250	1914
63	(129XOV1)X(CT5X00.2)	8686	27.68	15.67	467	291	175	1503
62	(S33XOV3)X(CT5X00.2)	8655	27.54	15.72	488	356	124	1472
37	(129XOV2)X(CT5X00.2)	8593	27.59	15.64	469	266	170	1640
79	(EL33X9450)X22/4	8579	28.97	14.83	599	306	371	1793
104	0166X621	8579	27.69	15.49	466	245	230	1549
81	(NB-1XOV3)XCT5B	8574	28.63	15.02	556	348	280	1537
109	128X7535	8549	27.29	15.65	512	291	369	1533
61	(CT9XOV3)X(CT5X00.2)	8511	28.40	15.00	578	342	287	1666
93	(NB-1XEL32)X(030XCT5)	8495	29.35	14.47	632	331	343	1861
73	(A1-12X0461)X(126X631)	8448	27.56	15.32	528	362	224	1491
72	(128XL-19)X22/4	8445	26.09	16.19	405	222	217	1422
115	129X712S	8406	28.42	14.75	512	270	229	1597
53	(NB-1XOV3)X9.8	8396	26.96	15.58	481	311	173	1517
39	(CT9XOV3)X712S	8391	28.11	14.93	538	308	215	1667
34	(133X0523)019N	8380	28.51	14.67	698	364	355	2124
10	128XOV3X(9450)	8374	27.63	15.17	523	304	245	1576
59	(128XOV3)X22/4	8373	27.40	15.30	540	309	293	1673

TABLE 6 VARIETY SCREENING TEST 4 121 VARIETIES(6REPS) LOGAN UTAH 1968 (CONT.)

		ACRE YIELD GROSS SUGAR	TONS BEETS	PERCENT SUGAR	INDEX	AMINO N	PPM NA	K
35	(OVXCT9A)XNB-1	8368	29.25	14.34	631	353	339	1718
75	(128XOV3)X(CT5X00.2)	8365	25.68	16.27	462	319	149	1528
101	308H01X0198S	8357	29.50	14.22	720	407	359	1948
83	(OVXCT9A)XCT5B	8333	27.60	15.06	502	360	297	1561
90	(CT9X22/4)XCT5B	8325	27.36	15.22	499	250	263	1660
99	(NB-1XEL32)X(126X631)	8324	27.90	14.89	603	347	244	1839
13	9122ACMS	8315	26.54	15.64	502	326	234	1476
51	(0156X030)X(CT5X00.2)	8310	26.80	15.47	481	291	174	1581
114	A[illegible]-1X712S	8298	28.81	14.42	535	256	304	1603
77	(EL31X030)X22/4	8291	26.87	15.45	549	310	303	1707
3	NB1XOV1X(0667)	8284	27.62	15.04	489	279	230	1443
23	(NB1XOV3)X130CTR	8271	26.87	15.37	495	278	198	1611
32	(OVXCT9A)X019N	8271	29.36	14.07	743	349	386	2239
19	NB-1XOV3 FC 601	8259	27.46	15.05	512	295	288	1456
107	UI HYBRID #7	8242	27.32	15.07	547	383	253	1382
89	(133X030)XCT5B	8232	25.97	15.81	426	231	282	1364
55	(133X0198)X9.8	8227	26.13	15.71	444	244	208	1501
2	OVXNB1 X(0667)	8225	30.52	13.50	654	318	374	1696
92	(133XA1-10)XCT5B	8206	26.98	15.23	521	357	232	1426
5	129XA1-10X(0667)	8194	26.92	15.27	408	233	164	1343
52	NB-1	8193	26.97	15.19	465	282	200	1412
116	41387X6713-1	8190	27.70	14.81	644	388	259	1881
100	(A1-10X0461)X(126X631)	8133	26.64	15.23	560	411	162	1518
84	(129XOV1)XCT5B	8128	27.13	14.96	460	230	269	1415
25	(128XOV2)X712S	8121	27.74	14.59	475	246	186	1512
4	133X030 X(0667)	8079	26.65	15.16	554	400	267	1358
33	(OVXCT9A)X019N	8064	26.41	15.27	596	322	259	1976
47	(128XL-19)XCT5	8061	25.59	15.73	426	217	201	1537
69	(129XOV1)X22/4	8042	26.57	15.13	511	265	287	1612
113	EL32X133	8039	26.46	15.24	629	429	293	1699
96	(EL31X030)X(030XCT5)	8038	26.75	15.00	530	306	291	1552
30	(128XOV3)X019N	8018	27.60	14.52	673	379	344	1909
38	(128XOV3)X712S	7979	27.31	14.63	539	306	225	1609

TABLE 6 VARIETY SCREENING TEST 4 121 VARIETIES(6REPS) LOGAN UTAH 1968(CONT.)

		ACRE YIELD GROSS SUGAR	TONS BEETS	PERCENT SUGAR	INDEX	AMINO N	PPM NA	K
12	7114 CHECK	7971	26.63	14.94	458	263	221	1368
71	(NB-1XEL32)X22/4	7963	26.72	14.91	629	377	347	1760
82	(S33XOV3)XCT5B	7956	26.11	15.25	535	339	255	1527
80	(128XOV3)XCT5B	7947	25.53	15.54	454	300	242	1277
44	(CT9X22/4)XCT9A	7927	26.51	14.94	497	271	275	1458
15	(CT9XE131)X(129XRF)	7888	25.99	15.21	436	236	222	1418
97	(A1-12X0198)X(030XCT5)	7848	26.25	14.91	512	247	274	1688
91	(129XA1-10)XCT5B	7840	25.55	15.33	437	219	224	1513
60	(NB-1XOV3)X22/4	7837	26.08	15.02	619	382	274	1792
31	(CT9XOV3)X019N	7836	27.47	14.29	763	403	339	2286
65	(CT9XOV3)X22/4	7834	26.88	14.56	616	336	327	1773
6	133XA1-10 X(0667)	7803	25.27	15.47	485	348	223	1276
14	U-1 COMMERCIAL	7790	25.53	15.31	471	292	221	1396
67	(OVXCT9A)X22/4	7787	26.46	14.71	609	333	309	1811
16	128XOV3 XKLRIN E	7766	26.41	14.70	643	363	330	1986
78	(133X030)X22/4	7738	25.58	15.17	552	325	296	1634
46	(S33XOV3)XCT5	7734	26.11	14.81	524	339	247	1405
98	(133X0198)X(030XCT5)	7732	25.71	15.05	466	238	254	1503
28	(CT9XOV3)X0461S	7703	24.19	15.93	460	350	183	1270
21	(129XL-19)XFC601	7698	24.83	15.50	478	220	258	1702
17	CT9XOV3 XKLIEN E	7661	27.18	14.14	714	347	347	2152
54	(OVXNB-1)X9.8	7638	26.86	14.21	528	343	357	1490
119	(503X5B)X(A1-1XRF)	7603	24.73	15.39	408	204	215	1401
66	(S33XOV3)X22/4	7599	25.53	14.87	583	368	249	1654
70	(NB-1XOV1)X22/4	7575	25.13	15.10	529	292	256	1688
111	(129X5B)X(C515XRF)	7567	24.70	15.30	398	203	172	1366
86	(A1-10X0461)XCT5B	7559	24.80	15.22	490	323	182	1434
48	(133X030)XCT5	7557	24.97	15.09	417	242	240	1249
85	(NB-1XEL32)XCT5B	7530	24.93	15.04	577	332	310	1669
27	(NB-1XOV3X0461S	7492	23.65	15.91	457	346	180	1266
8	OVXCT9A X(0461)	7457	24.84	15.02	539	376	205	1431
20	(S33XNB-1)XFC601	7405	25.76	14.37	475	260	251	1330
95	(A1-12X0461)X(030XCT5)	7391	24.45	15.13	531	328	343	1420

TABLE 6 VARIETY SCREENING TEST 4 121 VARIETIES(6REPS) LOGAN UTAH 1968(CONT.)

		ACRE YIELD					PPM	
		GROSS SUGAR	TONS BEETS	PERCENT SUGAR	INDEX	AMINO N	NA	K
118	(CT9X00.5)X(A1-1XRF)	7388	25.90	14.25	601	259	410	1774
1	S33XOV3X(0667)	7317	23.78	15.42	470	315	206	1344
94	(A1-10X0461)X(030XCT5)	7291	23.79	15.33	547	419	184	1393
120	(0187XEL31)X(503XRF)	7246	23.52	15.42	474	290	224	1438
68	(OVXNB-1)X22/4	7233	26.19	13.78	755	382	329	2156
26	(128XOV3)X0461S	7215	22.71	15.87	477	383	181	1236
57	(133X0523)XOV2	7211	23.72	15.23	496	253	249	1658
7	S33XOV3 X(0461)	7191	22.97	15.70	528	455	160	1272
87	(A1-12X0461)XCT5B	7114	23.25	15.29	484	329	250	1264
102	308H01XOV1	7109	23.20	15.29	591	416	209	1639
121	(S33X503)X(128XRF)	6983	23.56	14.80	455	228	203	1488
103	US22/3	6961	22.97	15.15	566	329	248	1770
88	(0156X030)XCT5B	6944	23.32	14.87	529	313	247	1528
9	133X030 X(0461)	6895	22.03	15.65	450	341	202	1175
29	(133X0523)X130CTR	6884	22.64	15.18	468	351	153	1208
117	(503XCT9)X(A1-1XRF)	6881	22.91	14.98	430	226	192	1433
40	(A1-12X0523)X0461S	6818	21.88	15.55	454	321	176	1287
22	133X0523XFC601	6639	21.80	15.24	451	240	230	1452
58	(S33XOV2)XOV2	6556	22.16	14.80	468	260	232	1395
108	129X0548	6533	21.95	14.87	424	234	196	1309
105	SP6322 LSR	6483	23.12	14.02	628	286	378	1827
106	EL 66P21	6386	20.71	15.45	491	298	260	1466
	MEAN OF ALL VARIETIES	7988	26.36	15.16	525	310	250	1573
	S.E. OF MEAN	310.56	0.99	0.19	27.29	30.72	26.75	64.13
	L.S.D.(5 PERCENT POINT)	878	2.80	0.54	78	86	76	182
	C.V. PERCENT	9.52	9.20	3.11	12.77	24.27	26.22	9.99
	CALCULATED F	4.35	4.47	7.35	8.46	3.36	5.15	12.05

Table 7. Individual Beet Progeny from Selfed 2224 Selections, Test 5, Logan, Utah, 1968.

Code No.	Description	Beet No.	Acre Yield Gross Sugar	Acre Yield Tons Beets	Sugar Percent	Impurity Index	PPM Amino N	PPM Na	PPM K
16	Parent 2224		7,778 a*	26.28 ab	14.79 ab	419 ghi	179 cdef	264 ef	1,384 de
11	High Index	7739-21	7,534 a	26.93 a	13.98 cde	535 bc	228 bc	334 cd	1,599 ab
13	High Index	7739-26	6,999 b	24.81 cd	14.11 cde	497 cdef	206 bcd	356 bcd	1,475 bcd
9	High Index	7739-06	6,966 b	25.06 bc	13.88 cde	499 cdef	232 b	336 cd	1,350 de
8	High Index	7739-04	6,957 b	24.95 bc	13.94 cde	564 ab	235 b	392 abc	1,637 a
6	Low Index	7737-21	6,921 b	23.39 def	14.76 ab	391 ghi	176 def	221 f	1,287 ef
10	High Index	7739-19	6,753 bc	24.15 cde	13.78 cde	463 efg	192 bcdef	333 cd	1,349 de
12	High Index	7739-25	6,674 bcd	23.19 f	14.38 bc	473 defg	197 bcde	378 abc	1,396 de
2	Low Index	7737-09	6,600 bcde	21.69 gh	15.19 a	360 i	145 f	290 de	1,195 fg
7	Low Index	7737-22	6,489 bcde	23.42 ef	13.85 cde	527 bcd	229 bc	411 ab	1,407 de
15	High Index	7739-29	6,310 cde	22.01 fg	14.33 bcd	513 bcde	230 bc	333 cd	1,548 abc
1	Low Index	7737-9	6,201 de	20.56 h	15.04 a	374 i	213 bcd	218 f	1,094 g
14	High Index	7739-28	6,098 ef	22.23 fg	13.70 e	594 a	310 a	414 ab	1,440 cd
4	Low Index	7737-15	5,671 fg	20.56 h	13.77 de	456 efg	190 bcdef	435 a	1,116 g
5	Low Index	7737-16	5,464 g	18.95 i	14.38 bc	375 i	151 ef	260 ef	1,184 fg
3	Low Index	7737-12	5,414 g	18.73 i	14.43 bc	446 fgh	216 bcd	214 f	1,403 de
Mean all Var.			6,552	22.93	14.28	468	208	324	1,366
S.E. Mean			226.97	0.67	0.26	27.34	22.16	29.76	60.08
C.V. %			6.00	5.03	3.14	10.12	18.45	15.90	7.62
Calculated F			17.71**	26.69**	6.40**	13.35**	6.19**	12.01**	14.34**
L.S.D. (5% point)			453.94	1.34	0.52	54.68	44.32	59.52	120.16

* Duncan's new multiple range test. Means that have the same suffix letter are not significantly different at the 5% point.

Low-index selections 1, 2, and 6 were highest in sugar, but were not significantly better than the parent population. Two other low-index selections (4 and 7) were among the entries having the lowest sugar percentage.

The selections having lowest impurity-index values were low-index selections 1, 2, 5, and 6. Again entries 4 and 7 deviated from the expected results based on selection pressure. Code 7 was significantly higher in impurities than the parent population and one high-index selection (10). Low-index selections tended to also be lower in amino N, Na and K. Again, however, codes 7 and 4 were exceptions.

The results of this test indicated that selection for impurity index could be made on an individual plant basis in the direction of high impurities. Otherwise, little difference was noted between the parent population and the selfed progenies of selected individual beets. It also showed that self pollination of selected beets did not always result in progenies that moved in the direction of the selection pressure.

Variety Test 6

Test 6 included selfed progenies of 16 individual beets. Ten beets were from high-impurity index selections made in previous years, two were from low-sugar selections, and four from high-sugar selections. All entries included in the test were in the S_3 generation.

High-index code 9, with the highest gross sugar, was not significantly different from the next seven progenies when means were placed in descending order (Table 8). These eight lines included five high-index (1, 3, 6, 7 & 9), two high-sugar (13 and 16), and one low-sugar selection (12). High-sugar selection 13 gave significance over the six lowest lines in the test for gross sugar. Low-sugar selection 11 was extremely low in gross sugar and significantly different than all others in the test.

The ranked means showed that yield in tons per acre was similar to the results for gross sugar. High-sugar selection code 15 had significantly greater sugar percentage than all other entries. Two other high-sugar selections, 16 and 13, were next highest in sugar percentage, but one sugar selection, 14, failed to show results from selection pressure. One low-sugar selection, code 11, was significantly lower than the other entries for this characteristic, but the other low-sugar selection, 12, had high sugar percentage.

Selection 15 was also significantly lower in impurity index than all other progenies. This line was lowest in Na and K and slightly below the general mean in amino N.

Line 4 had the highest impurity-index value, which was significantly higher than all other entries except for two other high-index

Table 8. Individual Beet Progeny from Selfed 4702 Selections, Test 6, Logan, Utah, 1968.

Code No.	Description	Beet No.	Acre Yield: Gross Sugar	Acre Yield: Tons Beets	Percent Sucrose	Impurity Index	PPM: Amino N	PPM: Na	PPM: K
9	High Index	11-4	7,114 a*	26.56 a	13.38 bcd	761 cd	388 cd	411 cde	1,920 bcde
6	High Index	8-17	7,088 a	26.61 a	13.29 bcd	738 cde	373 cde	407 cdef	1,888 cdef
13	High Sugar	12-11	6,658 ab	24.30 abc	13.70 bc	696 ef	299 efg	374 def	2,071 b
16	High Sugar	19-12	6,653 ab	24.07 abc	13.80 b	753 cde	447 c	329 ef	1,900 bcde
7	High Index	9-2	6,650 ab	25.15 ab	13.25 bcd	682 ef	235 g	409 cdef	2,070 b
12	Low Sugar	17-6	6,635 ab	24.24 abc	13.67 bc	599 f	248 g	404 cdef	1,708 ef
3	High Index	5-15	6,631 ab	24.75 abc	13.40 bcd	714 de	374 cde	435 cd	1,715 ef
1	High Index	1-7	6,594 ab	24.52 abc	13.42 bcd	688 ef	287 fg	460 cd	1,890 bcde
5	High Index	8-15	5,928 bc	22.66 bcd	13.05 bcd	703 de	237 g	554 ab	1,924 bcde
15	High Sugar	15-7	5,839 bc	19.91 def	14.67 a	555 g	330 def	223 g	1,608 f
10	High Index	13-14	5,556 c	21.89 cde	12.68 d	881 ab	405 cd	333 ef	2,352 a
8	High Index	9-12	5,397 cd	20.70 def	13.04 cd	890 ab	554 b	337 ef	1,952 bcd
2	High Index	5-7	5,158 cd	20.31 def	12.72 d	815 bcd	356 def	602 a	1,860 bcde
4	High Index	5-22	5,146 cd	19.60 ef	13.12 bcd	955 a	647 a	383 def	1,864 bcde
14	High Sugar	12-13	4,782 d	17.82 f	13.38 bcd	731 cde	343 def	462 cd	1,856 bcde
11	Low Sugar	14-19	2,202 e	9.98 g	11.00 e	838 bc	254 g	480 bc	1,979 bc
Gen. Mean all Var.			5,877	22.07	13.22	750	361	413	191
S.E. Mean Diff.			400.86	1.33	0.31	49.02	34.28	41.14	102.31
C.V. %			11.81	10.44	4.12	11.34	16.45	17.27	9.30
Calculated F			18.71	19.39	11.48	9.27	22.14	9.70	5.59
L.S.D. (5% point)			801.62	2.66	0.62	98.04	68.56	82.28	204.62

* Duncan's new multiple range test. Means that have the same suffix letter are not significantly different at the 5% point.

entries, 10 and 8. Two of the high index selections, 7 and 1, were among the entries with the lowest indices.

Selfing fixes the genes rapidly, making selection in selfed populations very difficult. This test shows that significant differences can be observed between individual beet progenies which have been selected for high or low sugar and impurity index, but all selections will not respond in the direction of selection pressure when they are selfed.

Variety Test 7

Test 7 is a study of individual beet recurrent selection using Mendelian male sterility (aa) as a crossing tool. In the parent population 4702 selections were made for high-impurity index, low-impurity index, and high sugar percentage. These selections were grown in separate isolations. All aa plants were tagged and seed was harvested individually from each plant. Progenies from five aa plants make up this test; two from the high-impurity index selection, two from the high-sugar selection, and one from a low-impurity index selection. There was no parental seed available, thus the parent could not be included for comparative purposes.

The yields per acre were comparatively high with no significant difference between high index, code 1, and high sugar, code 4, or between the two high-sugar selections 4 and 5 in gross sugar (Table 9). The only significant difference in tons per acre was due to the low yield (27.42) of the low-index entry.

The low-index selection was significantly better than all others in the test in sugar percentage. High-sugar code 4 did not significantly differ from high-sugar code 5 or high-index code 1 but was significantly better than high-index code 2 in sugar percentage. Low-index selection 3 was significantly better in quality than all other lines as evidenced by the low values for impurity index, amino N, Na and K. High-index selections 1 and 2 were highest in impurity-index values. This test gave evidence that individual beet recurrent selection resulted in positive selection pressure for high sugar, low impurity, and high impurity.

Variety Test 8

Test 8 consisted of two individual beet selections from variety 2224 and the parent population. Code 1 was from seed of eight aa beets selected individually for high-impurity index which were sib pollinated in a high-index group in isolation. Code 2 was from seed of 10 aa beets selected for high sugar and sibbed in a high-sugar group isolation.

The parent was significantly higher than both selections in gross sugar and higher in tons per acre than the high-sugar selection (Table 10).

The high-sugar selection was slightly lower than the parent for sucrose percentage and both of these entries significantly exceeded the index selection for this variable. The impurity-index value of the parent (2224) was lower than both selections, however, it was only significantly better than the high-index selection.

The test measured no differences between means for amino N and K. The extremely high Na (1069) for the high-index selection was significantly above that of the parent or sugar selection.

Grouped individual beet selections from population 2224 did not show improvement over the parent except in the direction of higher impurities.

Table 9. Individual Beet Progeny Selections from 4702, Test 7, Farmington, Utah, 1968.

Code No.	Description	Beet No.	Acre Yield Gross Sugar	Acre Yield Tons Beets	Percent Sucrose	Impurity Index	PPM Amino N	PPM Na	PPM K
01	High Index	8-12	11,085	38.90	14.23	865	449	777	2,021
04	High Sugar	18-0	10,704	36.91	14.48	807	423	708	1,988
05	High Sugar	10-11	10,588	37.93	13.94	814	368	803	1,916
02	High Index	15-2	9,437	37.53	12.63	960	337	1053	1,915
03	Low Index	20-13	8,461	27.42	15.43	535	316	386	1,494
Mean all Var.			10,055	35.74	14.15	796	37.87	746	1,866
S.E. Mean Diff.			432	1.43	0.34	52.30	35.51	61.03	67.54
C.V. %			7.44	6.95	4.18	11.38	16.24	14.18	6.27
Calculated F			12.56	21.54	17.61	18.26	4.93	30.80	20.25
L.S.D. (5% point)			864	2.86	0.68	104.60	71.02	122.06	135.08

Table 10. Individual Beet Progeny Selections from 2224, Test 8, Farmington, Utah, 1968.

Code No.	Description	Beet No.	Acre Yield Gross Sugar	Acre Yield Tons Beets	Percent Sucrose	Impurity Index	PPM Amino N	PPM Na	PPM K
03	2224 Parent		11,852	42.61	13.90	800	370	828	1,822
02	High Sugar	2-4aa	10,810	39.49	13.67	852	372	933	1,834
01	High Index	29-1aa	10,659	41.70	12.75	948	371	1068	1,805
Mean all Var.			11,107	41.27	13.44	867	371	943	1,820
S.E. Mean Diff.			452	1.09	0.28	36.76	NS	65.29	NS
C.V. %			7.05	4.57	2.77	7.34	1.14	11.99	4.84
Calculated F			4.13	4.36	9.48	8.29	4.08	6.86	NS
L.S.D. (5% point)			904	2.18	0.56	73.52	NS	120.58	NS

Resistance in Sugarbeet to Infection by Curly-Top Virus

D. L. Mumford

It has been suggested that resistance in sugarbeet to curly-top virus consists not only of a tolerance after infection but also a tendency to escape infection. In the course of evaluating lines of sugarbeet in the greenhouse, an attempt has been made to find lines with such a tendency to escape infection. The value of this type of resistance is that it may be less subject to being overcome by the appearance of new strains of the virus.

Two separate tests of several lines from John Gaskill's breeding program and a single test of several lines from Clair Theurer's program have indicated differences between lines in their tendency to become infected. In both tests of the Ft. Collins' material, a group giving 100% infection was separated from a group giving less than 100% infection. Of twenty lines from Logan tested, 19 averaged 7% escapes with a range of 0 to 20%. The other line, selected for further testing, had 38% escapes.

These types of evaluations, where viruliferous hoppers are forced to feed on all plants, will not detect a possible tendency to escape infection due to vector host preference. However, the results so far seem to justify additional evaluation and particularly the subsequent testing of progeny from selected lines.

Greenhouse Tests on the Effects of Systemic Insecticides on Leafhopper Mortality and Curly-Top Infection

D. L. Mumford and C. H. Smith

In sugarbeet growing areas where the level of resistance to curly top is not sufficiently high, there has been an increase in the last three years in the use of systemic insecticides to control curly top by reducing leafhopper populations in the beet field. Many field experiments have indicated considerable success with such treatments.

Experiments at Logan were carried out in the greenhouse to observe, under controlled conditions, the effects of systemic insecticides on leafhopper mortality and the resulting reduction in curly-top infection. Treatments consisted of the placement of a systemic insecticide in soil in deep pots at a depth of 3 inches below the seeds. The rate of application was based on a field rate of 2 lbs active ingredient per acre of a 10% granular material. Each 8-inch pot received .4 g of the 10% material distributed in 2 bands across the pot with 2 seedlings grown above each band. Leafhoppers were caged singly on each plant and the number of dead hoppers determined at intervals thereafter.

The results in Table 1 indicate the effectiveness of systemic insecticides in reducing leafhopper populations. From 74 to 97 percent of hoppers caged on sugarbeet seedlings 10 days old or older were dead in less than 24 hrs. where Thimet insecticide was used. Similar reductions in hopper populations in the field would have a long range effect of limiting the number of females returning to the overwintering areas and an accompanying reduction in the spring reproduction. The fact that the effectiveness of the insecticides did not appear to decrease even on seedlings 105 days old may not be highly correlated with performance in the field. The pots in these experiments were kept in saucers in which they were watered. This may have reduced leaching of the chemical that would ordinarily occur in the field. It should also be pointed out that the high mortality in some tests in the untreated check was probably due to occasional high greenhouse temperature.

The data suggest that for a period of at least four days after emergence, the insecticides are not present in the cotyledons in sufficient quantity to kill leafhoppers. Where the practice in the field is to place the insecticide 6 inches below the seed, this period of ineffectiveness may be longer. The seedlings are most susceptible during this time and systemic insecticides may be of little value against a heavy migration of viruliferous hoppers during this same period.

The leafhoppers used for the tests on 10 and 21 day-old seedlings were viruliferous. Table 2 contains data on percentage seedling infection in these tests. In these experiments Thimet reduced infection approximately 50 percent. An additional reduction in infection not

Table 1. Leafhopper mortality from feeding on sugarbeet seedlings treated with systemic insecticides.

Treatment	Seedling Age	Percentage hoppers dead after: [d] 6 hrs	1 day	4 days	6 days
None	4 days[a]	0	3	28	43
Disyston	"	0	4	29	60
Thimet	"	0	3	23	90
None	10 days[b]	3	11	15	24
Disyston	"	3	14	49	75
Thimet	"	31	78	98	100
None	21 days[c]	3	5	13	30
Disyston	"	0	20	53	75
Thimet	"	35	92	100	100
None	56 days	0	13	31	46
Disyston	"	0	17	58	75
Thimet	"	20	74	100	100
None	77 days	3	5	22	27
Disyston	"	3	8	72	78
Thimet	"	53	97	100	100
None	105 days	8	11	19	19
Disyston	"	6	42	90	95
Thimet	"	71	94	100	100

[a] Hoppers caged on entire plant after emergence
[b] Hoppers caged on cotyledons
[c] Hoppers caged on true leaves
[d] Data are based on 40 hoppers per treatment

present in greenhouse tests might be realized in field situations. The reduction in hopper population from initial feeding on treated plants would result in fewer plants subsequently visited by hoppers and therefore subject to infection.

Table 2. Infection in sugarbeet seedlings treated with systemic insecticides from feeding by viruliferous leafhoppers.

Treatment	Seedling Age	Percentage infection after 14 days
Check	10 days	97
Disyston	"	74
Thimet	"	43
Check	21 days	63
Disyston	"	75
Thimet	"	34

VIRUS DISEASES OF SUGARBEETS
by Lynn L. Hoefert

Beet Mosaic

A cytological study of leaves infected with beet mosaic was begun. Infected cells were previously shown to undergo chloroplast degeneration as is common in mosaic diseases (Esau, 1944, 1968), but no electron microscopic observations had been carried out. In the present study, infected cells were found to contain cytoplasmic inclusions in the form of pinwheels and bundles which were shown to be proteinaceous inclusions. In addition, virus-like particles were observed in infected leaf cells. A preliminary note regarding the appearance of protein and virus-like inclusions will soon be published (Hoefert, 1969; Virology, in press). Chloroplast degeneration was noted at the ultrastructural level and further work on this and other aspects of beet mosaic virus cytopathology are anticipated.

CYTOLOGICAL STUDIES OF CYTOPLASMIC MALE STERILITY
by Lynn L. Hoefert

All efforts in studying cytoplasmic male sterility have been directed toward developmental aspects of normal pollen cytology. Until the characteristics of normal pollen development have been fully elucidated, little information can be gained about male-sterile pollen and its development.

The first report on Beta pollen development describes the cytoplasmic structure of pollen grains and developing microspores (Hoefert, 1969; Amer. J. Bot., in press). The next report describes the binucleate pollen grain and how it develops (Hoefert and Lang, in preparation). A microspore becomes a pollen grain after the mitotic division that results in a binucleate condition. A wall separates the generative cell from the vegetative cytoplasm and at first, the generative cell is attached to the intine of the pollen wall. The generative cell is then released from the intine and the generative cell, enclosed by its wall, lies free in the vegetative cytoplasm. Thereafter, the generative wall disappears gradually leaving the generative cell separated from the vegetative cytoplasm by two plasma membranes. The generative cell assumes an ellipsoidal shape prio to the last mitotic division which, in sugarbeet, yields a trinucleate pollen grain with a vegetative or tube nucleus and two sperm nuclei. The sperm nuclei actually are cells, ellipsoidal in shape, nucleate, and each contains its own cytoplasm and organelles. The fine structure of sperm cells in mature, trinucleate pollen grains has not been adequately described by other investigators and is the subject of a note in preparation (Hoefert, in preparation). The ellipsoidal sperm cells possess peripheral microtubules that may function in sperm cell motility. Current efforts are

directed toward following the degenerative changes in tapetal cells that surround the developing microspores and are thought to supply nutrients to the microspores. Attempts are also in progress to discover where and how the heavy outer coat or exine of the pollen grain is formed. The tapetal degeneration and associated events are particularly important because this stage is probably the key to cytoplasmic male sterility (Artschwager, 1947).

Artschwager, E. 1947. J. Agr. Res. 34:1-25.

Esau, K. 1944. J. Agr. Res. 69:95-117.

Esau, K. 1968. Viruses in Plant Hosts. U. Wisc. Press, Madison. 225 p.

Photosynthesis and Respiration Studies on Sugarbeets

Myron Stout

The interaction of light intensity and carbon dioxide concentration on the net accumulation rate of intact sugarbeet plants provides a more discriminating technique in assessing photosynthetic behavior. If respiration rate measurements are plotted below zero on the net accumulation scale, the intercept of the curve on the CO_2 concentration scale provides an approximate value of the CO_2 concentration at compensation point for a given light intensity.

A comparison of net accumulation rate values at different CO_2 concentrations and light intensities was made of beets having leaves of different ages. Only young expanding leaves were left on some beets. Fully expanded (intermediate) aged leaves or older, but not senescent leaves, were left on others.

The respiration rate of the youngest leaves was highest. Intermediate aged leaves were intermediate and the oldest leaves were lowest in respiration rate.

Net accumulation rate of the intermediate aged leaves was highest. The young leaves were intermediate in net accumulation rate and the older leaves were lowest in net accumulation rate. The data were quite consistent at four CO_2 concentrations and three light intensities. The CO_2 concentration at compensation point was higher at the lower light intensities.

Extensive tests were run on four varieties of sugarbeets at five light intensities and six CO_2 concentrations. The varieties were: a dark green diploid, 4162, a homodiploid, 6600; a tetraploid, 1540; and a light green (chlorina) mutant, 822-1. Light intensities were: 510, 950, 1600, 2450 and 4150 foot-candles. CO_2 concentrations were 83, 105, 157, 270, 408, and 560 ppm. The plotted data produces a sort of "metabolic fingerprint" of the plant.

Net accumulation rates were highest for the dark green variety 4162 and the tetraploid variety 1540. The homodiploid variety 6600 was intermediate and the chlorina variety 822-1 was lowest at all light intensities and CO_2 concentration. Respiration rates were all higher at 157 ppm than at 408 ppm of CO_2. The dark green variety had a higher respiration rate. The homodiploid variety was intermediate and the chlorina variety was lowest in respiration rate.

Increased CO_2 concentration increased net accumulation rates relatively little at low light intensity. At higher light intensity the rates were increased much more by higher CO_2 concentration. There

was a rapid decline in the CO_2 con centration at compensation point as light intensities were increased up to about 1500 ft-c. A further increase in light intensity reduced the CO_2 concentration only slightly at compensation point.

Rapid Methods for Evaluating Individual Sugarbeets for Quality Factors and Respiration Rate

Myron Stout

Several improvements were made in laboratory techniques for individual sugarbeet analysis this past year. (1) A gauge was made to accurately measure a uniform weight of samples for analysis. (2) A machine was developed to cut the sample into a spiral ribbon of tissue so that one slice with a knife reduced the sample into 30-35 slices suitable for blending. (3) Airflow through blender motor housing was increased eight times, thereby reducing over-heating and burnout. (4) One extra double blade was added to each blender cup to insure pick-up of pieces in the bottom and accomplish more rapid and complete blending. (5) Blenders are now operated by time clocks. (6) Cold water from a spring-loaded valve rinses and cools blender cups. (7) A temperature controlled bath cools samples during digestion to 20 C so that no cooling occurs following filtration. This practically eliminates cloudy filtrates.

SUGARBEET RESEARCH

1968 Report

Section D

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Cooperation:

Colorado Agricultural Experiment Station
American Crystal Sugar Company
Great Western Sugar Company
Holly Sugar Corporation
Spreckels Sugar Company

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CONTENTS

DEVELOPMENT AND EVALUATION OF SUGARBEET BREEDING MATERIAL AND VARIETIES CARRYING RESISTANCE TO BOTH LEAF SPOT AND CURLY TOP, 1968 [1/]

J. O. Gaskill, D. L. Mumford, and G. E. Coe [2/]

Introduction

Construction of a new, million-dollar, USDA, Crops Research Facility was nearly completed by the end of 1968. This complex consists of two units: (1) The Crops Research Laboratory (main building, headhouse, and greenhouses) on the Colorado State University Campus; and (2) The Sugar Laboratory on the CSU Agronomy Research Center. No. (1) is for use by three research units of the Crops Research Division of ARS: Sugarbeet Investigations, Forage and Range Investigations, and Weed Investigations (Sugarbeet). No. (2) is assigned to Sugarbeet Investigations. Occupancy of the entire complex is nearing completion (February, 1969). Photographs of this facility are to appear in Sugarbeet Research, 1967 Report (in press).

[1/] Except for the Introduction, this report pertains to breeding and evaluation work performed at Fort Collins, Colorado, and to cooperative tests conducted elsewhere by numerous investigators, with results compiled at Fort Collins. The work at Fort Collins was performed by Sugarbeet Investigations, Crops Research Division, ARS, USDA, in cooperation with the Colorado Agricultural Experiment Station (Project 149) and the Beet Sugar Development Foundation (Project 25). The assistance of Luther W. Lawson and Beverlie A. Nelsen, Agricultural Research Technician and Statistical Clerk, respectively, in the Crops Research Division at Fort Collins, is acknowledged.

[2/] Research Plant Pathologist, Fort Collins, Colorado; Plant Pathologist, Logan, Utah; and Geneticist, Beltsville, Maryland, respectively. All are members of the staff of Sugarbeet Investigations, Crops Research Division, ARS, USDA.

The Hospital Farm at Fort Collins, which had been used for sugarbeet research (principally in the pathologic category) for approximately 50 years, was vacated by Sugarbeet Investigations at the end of 1968. Leasing arrangements have been made, through the Beet Sugar Development Foundation, for replacement land near the Agronomy Research Center. A pole building (with metal exterior), including a shop and a machinery storage area, has been constructed on the Agronomy Research Center. This building, together with the Sugar Laboratory, will house equipment, mother beets, and seed formerly stored on the Hospital Farm.

The year, 1968, has been a momentous one with respect to the sugarbeet research potential at Fort Collins. Unfortunately, however, Federal employment ceilings have prevented the employment of the administrative and maintenance personnel needed for efficient preparation and use of the new buildings. The administrative and operational burdens thus imposed on the Research Plant Pathologist (Sugarbeet Investigations) at Fort Collins and his assistants have interfered seriously with the pathologic research program during the last 12 months. This interference has been especially serious during the last 4 months (i.e. November, 1968, through February, 1969, approximately). One of the important consequences has been our inability to summarize 1968 experimental results properly. This will be reflected in the brevity of our report on research. Another important consequence is curtailment of other phases of the pathologic research program. This is already painfully apparent in the greenhouse, and substantial curtailment of field work in 1969 now appears to be inevitable.

Research Program

Insofar as possible, the program of breeding for combined resistance to leaf spot and curly top (LSR-CTR) at Fort Collins, Colorado, and the evaluation of LSR-CTR material at Fort Collins and elsewhere in 1968 followed essentially the same plan as in 1967. Field tests on the Hospital Farm in 1968 were generally good, and much valuable information was obtained. Curly top resistance evaluation and selection work, conducted by Dr. D. L. Mumford, involved more than 300 field plots near Thatcher, Utah, and a large number of individually inoculated seedlings in the greenhouse at Logan, Utah. Dr. J. C. Theurer, Geneticist, at the Logan Station assisted by maintaining isolated plantings of selected mother beets for seed production. Dr. G. E. Coe conducted a variety test, and several sugar companies also cooperated in conducting variety tests. The West Coast Beet Seed Company, Salem, Oregon, assisted in the research by maintaining a block of overwintered seed plots for the purpose of facilitating the study of flowering-plant characters.

Because of limitations described in the Introduction, our report of results obtained in the "LSR-CTR Project" during 1968 will be limited to a summary of results for the cooperative tests of LSR-CTR varieties.

Cooperative Tests of LSR-CTR Varieties

Results of cooperative tests of LSR-CTR varieties were reported as follows:

Agency	No. of tests	
	Agronomic	Observational
American Crystal Sugar Company	2	
Great Western Sugar Company	1	
Holly Sugar Corporation	2	2
Spreckels Sugar Company	2	
Sugarbeet Investigations, ARS, USDA	2	1

The varieties evaluated are described in Table 1, and the results of the tests are summarized in Tables 2-5, inclusive.

The high light of the results of these tests is the outstanding gross sucrose yield of the three hybrids having FC(504 x 502/2) as the female parent--i.e. entries 2, 3, and 7. The average gross sucrose yield for those three entries, expressed as percent of that of the standard variety [SL(129 x 133) x SP 6322-0], was 108.2, 107.9, and 106.4, respectively. The average sucrose percentage for entries 2, 3, and 7, expressed on the same basis, was 104.7, 101.4, and 102.7. Since entry 7, the LSR check, has no resistance to curly top, it would be unsuitable for commercial use in areas where curly top is a threat. However, it could be useful in some other areas, particularly where both leaf spot (Cercospora) and black root (Aphanomyces) are problems. As shown in Table 5, entries 2 and 3 have moderate resistance to both leaf spot and curly top.

FC 502/2, a component of entries 2, 3, and 7, has been disappointing in seed production in Oregon. However, progress at Fort Collins, in the development of an advanced generation of FC(504 x 502/2) and its CMS equivalent, is encouraging. This development seems promising as a means of overcoming the poor seed-producing capability of FC 502/2.

Table 1.--Description of material in cooperative evaluation tests of LSR-CTR varieties, 1968. [a/]

Entry no.	Description [b/]
1	SL(129 x 133) x SP 6322-0; monogerm; LSR-CTR-BRR; furnished by F & M.
2	FC(504 x 502/2) x FC 901; monogerm; LSR-CTR.
3	FC(504 x 502/2) x McF. 663; monogerm; LSR-CTR.
4	(FC 601 x SP 632028s1) x FC 901; monogerm; LSR-CTR.
5	(FC 601 x SP 632028s1) x McF. 663; monogerm; LSR-CTR.
6	FC(502/2 x 601) x McF. 663; monogerm; LSR-CTR.
7	FC(504 x 502/2) x SP 6322-0; monogerm; LSR-BRR; LSR check.
8	US H9B; monogerm; CTR, bolting resistant, and yellows resistant; furnished by J. S. McFarlane; CTR check.

a/ Most tests included a "local check", furnished by the cooperator, in addition to the varieties listed in this table.

b/ Preplanting classification for disease resistance, though varying widely in degree, is indicated as follows: BRR = black root resistant (i.e. resistant to Aphanomyces-type black root); CTR = curly top resistant; LSR = leaf spot resistant.

Table 2.--Summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1968; as percent of the standard variety, SL(129 x 133) x SP 6322-0.

Gross Sucrose Yield

Test no., state, and locality	Rel[a/]	Diseases[b/] BR	CT	LS	Rh	No. reps	Entry no. 1	2	3	4	5	6	7	8	Loc[c/] ck.	LSD[d/] (.05)
(1) Ariz., Willcox	fg		3			10	100	133	122	113	122	123	116	126	112	12
(2) Calif., Gerber	g					9	100	117	116	111	118	117	108	108	105	12
(3) Calif., Porterville	f		1			10	100	107	119	112	110	114	102	107	94	16
(4) Colo., Ft. Collins	vg		3			9	100	117	106	97	102	102	121	90	102	8
(5) Colo., Longmont	g					4	100*	96*	91*	90*	88*	93*	87*	100*		11*
(6) Colo., Rocky Ford	fg					8	100	93	95	82	75	86	88	89		13
(7) Colo., Two Buttes	vg					8	100	105	113	96	100	102	101	116		9
(8) Md., Beltsville	f	1	3		1	3	100	107	101	94	87	103	133	55	106	17
(9) Texas, Hereford	vg					9	100	99	108	88	98	103	102	107	100	11
Average							100.0	108.2	107.9	98.1	100.0	104.8	106.4	99.8		

[a/] Reliability of test: f = fair; fg = fairly good; g = good; vg = very good.

[b/] Disease exposure: BR = black root (Aphanomyces cochlioides); CT = curly top (virus); LS = leaf spot (Cercospora beticola); Rh = Rhizoctonia root or crown rot; 1 = mild; 2 = moderate; 3 = severe. No numerical entry for a disease indicates negligible effects, if any.

[c/] Local checks were as follows (test numbers in parentheses): (1) A65173; (2) HH 9; (3) S-301H; (4) GW 674-56C; (8) SP 5822-0; (9) HH-10.

[d/] LSD (.05) expressed as percent of the gross sucrose yield of the standard variety (entry no. 1).

* = Recoverable sucrose.

Table 3.--Summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1968; as percent of the standard variety, SL(129 x 133) x SP 6322-0.

Beet Yield

Test no., state, and locality	Rel[a]	Diseases[b] BR	CT	LS	Rh	No. reps	Entry no. 1	2	3	4	5	6	7	8	Loc. ck.[c]	LSD[d] (.05)
(1) Ariz., Willcox	fg		3			10	100	129	118	111	118	118	109	131	109	12
(2) Calif., Gerber	g					9	100	110	113	104	114	113	105	110	108	9
(3) Calif.,Porterville	f		1			10	100	102	121	111	109	112	101	111	94	16
(4) Colo., Ft. Collins	vg		3			9	100	112	103	95	100	99	116	92	100	7
(5) Colo., Longmont	g					4	100	93	94	86	89	89	88	105		12
(6) Colo., Rocky Ford	fg					8	100	86	91	75	75	82	83	90		11
(7) Colo., Two Buttes	vg					8	100	102	112	92	98	98	101	115		9
(8) Md., Beltsville	f	1	3		1	3	100	106	100	88	87	98	123	68	101	17
(9) Texas, Hereford	vg					9	100	91	107	79	91	97	100	106	101	9
Average							100.0	103.4	106.6	93.4	97.9	100.7	102.9	103.1		

[a] Reliability of test: f = fair; fg = fairly good; g = good; vg = very good.

[b] Disease exposure: BR = black root (Aphanomyces cochlioides); CT = curly top (virus); LS = leaf spot (Cercospora beticola); Rh = Rhizoctonia root or crown rot; 1 = mild; 2 = moderate; 3 = severe. No numerical entry for a disease indicates negligible effects, if any.

[c] Local checks were as follows (test numbers in parentheses): (1) A65173; (2) HH9; (3) S-301H; (4) GW 674-56C; (8) SP 5822-0; (9) HH-10.

[d] LSD (.05) expressed as percent of the beet yield of the standard variety (entry no. 1).

Table 4.--Summary of harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1968; as percent of the standard variety, SL(129 x 133) x SP 6322-0.

Sucrose Percentage

Test no., state, and locality	Rel[a]	Diseases[b] BR	CT	LS	Rh	No. reps	Entry no. 1	2	3	4	5	6	7	8	Loc. ck.[c]	LSD[d] (.05)
(1) Ariz., Willcox	fg			3		10	100	103	103	101	103	105	103	96	102	3
(2) Calif., Gerber	g					9	100	106	103	107	103	104	103	98	97	5
(3) Calif.,Porterville	f			1		10	100	105	98	101	101	102	101	97	100	NS
(4) Colo., Ft. Collins	vg			3		9	100	104	102	103	103	103	104	97	102	2
(5) Colo., Longmont	g					4	100	103	98	102	101	103	98	97		4
(6) Colo., Rocky Ford	fg					8	100	108	105	110	101	104	106	99		7
(7) Colo., Two Buttes	vg					8	100	103	101	104	103	104	99	100		4
(8) Md., Beltsville	f	1		3	1	3	100	101	101	106	100	105	108	81	106	8
(9) Texas, Hereford	vg					9	100	109	102	112	108	107	102	102	99	5
Average							100.0	104.7	101.4	105.1	102.6	104.1	102.7	96.3		

[a] Reliability of test: f = fair; fg = fairly good; g = good; vg = very good.

[b] Disease exposure: BR = black root (*Aphanomyces cochlioides*); CT = curly top (virus); LS = leaf spot (*Cercospora beticola*); Rh = *Rhizoctonia* root or crown rot; 1 = mild; 2 = moderate; 3 = severe. No numerical entry for a disease indicates negligible effects, if any.

[c] Local checks were as follows (test numbers in parentheses): (1) A65173; (2) HH 9; (3) S-301H; (4) GW 674-56C; (8) SP 5822-0; (9) HH-10.

[d] LSD (.05) expressed as percent of the sucrose percentage of the standard variety (entry no. 1).

Table 5.--Summary of leaf spot and curly top resistance results, cooperative tests of LSR-CTR varieties, 1968; disease exposure intensified artificially in each test.

Description	Entry no.	Leaf spot grades [a/]				Curly top grades [b/]		
		Ft. Collins, Colo. (Ag.test)	Beltsville, Md. (Ag.test)	Hereford, Texas (Nursery)	Aver.	Thatcher, Utah (Nursery)	Sheridan, Wyo. (Nursery)	Aver.
No. of replications		9	3			2		
SL(129 x 133)x SP 6322-0	1	4.1	4.7	2.0	3.6	6.0	3.5	4.8
FC(504 x 502/2)x FC 901	2	3.6	4.2	1.5	3.1	5.5	2.0	3.8
FC(504 x 502/2)x McF. 663	3	3.8	3.5	2.5	3.3	5.5	2.5	4.0
(FC 601 x SP 632028s1)x FC 901	4	4.0	4.5	3.5	4.0	5.0	2.0	3.5
(FC 601 x SP 632028s1)x McF. 663	5	3.9	3.9	3.0	3.6	5.0	3.0	4.0
FC(502/2 x 601)x McF. 663	6	3.7	2.9	2.5	3.0	5.5	3.0	4.3
FC(504 x 502/2)x SP 6322-0; LSR ck.	7	2.6	2.9	2.5	2.7	6.5	4.5	5.5
US H9B; CTR ck.	8	5.3	6.0	3.5	4.9	5.0	2.5	3.8

[a/] Lower number = greater resistance. At Fort Collins and Beltsville, 0 = no leaf spot, and 10 = complete defoliation by leaf spot.

[b/] Lower number = greater resistance. At Thatcher, 0 = no observable curly top infection, and 9 = all plants dead due to curly top.

BREEDING FOR RHIZOCTONIA RESISTANCE, 1968 [1/]

John O. Gaskill

High Lights of Results

1. Two Rhizoctonia resistant sugarbeet lines, developed at Fort Collins (FC 701 and FC 702), were officially released in 1968.

2. FC 701/2 (SP 671007-0) and FC 702/2 (SP 671008-0)--products of additional selection for Rhizoctonia resistance, from FC 701 and FC 702, respectively--were made available to the member companies of the Beet Sugar Development Foundation in 1968 for increase and other purposes.

3. Results obtained in 1968 confirmed earlier indications that substantial improvement in Rhizoctonia resistance had been achieved by selection from more than one type of sugarbeet variety.

4. The results obtained for one F_1 hybrid (resistant x susceptible lines) indicated partial dominance for resistance. The resistance of a similar F_1 hybrid was loosely classed as intermediate.

5. The results for a series of F_3 lines indicated, tentatively, that resistance can be transferred from resistant to susceptible lines with relative ease.

1/ Research conducted by the Crops Research Division, ARS, USDA, at Fort Collins, Colorado, in cooperation with the Colorado Agricultural Experiment Station and the Beet Sugar Development Foundation (a part of Foundation Project 25).

INHERITANCE OF SUCROSE CONTENT AND WEIGHT OF ROOTS FOR CROSSES BETWEEN THREE SUGARBEET INBREDS

Richard J. Hecker and Grace W. Maag

Sucrose content and root weight in sugarbeet are generally considered to be conditioned by multiple genetic factors. Information about the number of genes conditioning these characters, magnitude of gene effects, and the type of gene action would lend some insight as to further steps which could be taken in biochemical research and breeding of sugarbeet for improved sucrose content and root weight.

From the standpoint of physiological genetics, the development and functioning of an organism consists essentially of an integrated system of chemical reactions controlled in some manner by genes. In investigating the role of genes, the physiological geneticist usually attempts to determine the physiological and biochemical bases of previously genetically defined hereditary traits. The primary objective of this study was to identify genotypes which were different for only one, two, or three genes for sucrose and weight. This would then allow biochemical and physiological studies to be initiated on genotypes with known gene differences for the purpose of studying some of the major steps or pathways in sucrose synthesis, storage, and root growth. A secondary purpose of the study was to evaluate the partitioning method of genetic analysis as a means of accurately determining the inheritance of sucrose content and root yield.

The plant material used in this study consisted of three inbred lines and their cytoplasmic male sterile (CMS) equivalents and all possible combinations of F_1, F_2, and backcross (B_1) generations. Reciprocal F_1's were also included. All these populations with their means for sucrose and weight are listed in Tables 1 and 3. All 22 populations were planted on April 17, 1967 at the Agronomy Research Center of Colorado State University in a randomized complete block design with 40 replications. Each block was a single row, 20 feet long, separated by a row of relatively low vigor common competitor. Plants within the row were spaced from 10 to 12 inches and the stands were good. Eleven competitive plants were harvested from each plot and individually weighed and analyzed for sucrose content.

From the 440 plants in each population it was possible to calculate for both sucrose and weight their means, total variances, total within plot variances, and frequency distributions. Estimates of the environmental variance for each character were developed (details later) from the nonsegregating populations. The total genetic variance then of each of the segregating populations was the difference between the total within plot variance and the estimated environmental variance. Thus for each of the segregating populations we had the experimental means and frequency distributions and estimates of their total genetic variance. Estimates of the same statistics based on a particular genetic hypothesis were made using the partitioning method and were called the theoretic means, total genetic variances, and frequency distributions. The obtained and the theoretic means, total genetic variances, and frequency distributions were then compared in order to test the particular genetic hypothesis. Any

preliminary information available from the data which might help in formulating a more accurate genetic hypothesis is most useful. This information comes from a study of obtained means, variances, and frequency distributions.

In applying the partitioning method of genetic analysis the logical approach is to start with the simplest possible genetic hypothesis that is compatible with the obtained data. The method as applied in this case also assumed that the environmental frequency distributions were normal. Also since the computed theoretic frequency distributions did not contain replication varibility this source of variation was removed from the obtained data for each population.

Sucrose Percentage

After replication effects were removed within each obtained frequency distribution, the distribution for all populations were acceptably normal. This allowed us to procede with the genetic analysis using the partitioning method. From a study of the means and variances it was evident that there must be more than one gene involved in the inheritance of sucrose in all of the three possible crosses, so the first genetic hypothesis tested were 2-gene models. With a 2-gene model there were nine genotypes in the F_2 and four genotypes in each of the B_1's. The frequencies of these genotypes in these generations are those expected in any dihybrid F_2 and B_1's. The means of these genotypes are specified by the genetic model. A study of the obtained means indicated that in all three crosses there was partial dominance for higher sucrose. There was also an indication of some inter-locus interaction or epistasis present in the three crosses. The initial 2-gene models which were tested included only parital dominance of the degree shown by the obtained means. From the means of the genotypes and their expected frequencies, using methods of Powers, it was possible to calculate the theoretic means of all F_2 or B_1 generations. The expected total genetic variances were also computed from these same genotypic means and frequencies. These calculated means and total genetic variances, which Powers designates as theoretic means and genetic variances, were then compared with the obtained means and total genetic variances and statistical tests for difference were made. The obtained total genetic variances were obtained by subtracting the pooled total within plot variance of the nonsegregating populations from the total within plot variances of the individual segregating generations. After development and testing of numerous 2-gene models which included dominance of varying degrees, nonisodirectional effects, and epistasis, it was evident that none of the 2-gene models adequately accounted for the obtained variability of the various segregating generations. It was evident that genetic models involving more than two genes would have to be used to explain the obtained data.

Models for three genes were then developed for sucrose content. One 3-gene model for sucrose adequately described the variability for the segregating generations of the cross 52-305 X 52-407. A 3-gene model could not be developed which adequately described the variability in the

Table 1. Populations, means, total within plot variances, and total genetic variances for sucrose percentage.

Pop. No.	Population	Mean (%)	Total within plot variance	Total genetic variance	Broad sense heritability (h^2)
1	52-305 CMS	17.77	0.67982		
2	52-305	17.89	0.64130		
3	52-407 CMS	14.90	0.89662		
4	52-407	14.74	0.63745		
5	52-307 CMS	17.12	0.78874		
6	52-307	17.15	0.63377		
7	(52-305 CMS X 52-407), F_1	16.98	0.63617		
8	(52-407 CMS X 52-305), F_1	17.21	0.64019		
9	[(52-305 X 52-407), F_1], F_2	16.51	1.15856	0.51247	0.44
10	[(52-305 CMS X 52-407), F_1 X 52-305], B_1	17.17	0.82655	0.19046	0.23
11	[(52-305 CMS X 52-407), F_1 X 52-407], B_1	15.72	0.95931	0.31322	0.33
12	(52-305 CMS X 52-307), F_1	17.81	0.66750		
13	(52-307 CMS X 52-305), F_1	17.82	0.63249		
14	[(52-305 X 52-307), F_1], F_2	17.57	1.02478	0.37869	0.37
15	[(52-305 CMS X 52-307), F_1 X 52-305], B_1	17.46	0.94745	0.30136	0.32
16	[(52-305 CMS X 52-307), F_1 X 52-307], B_1	17.53	1.18744	0.54135	0.46
17	(52-307 CMS X 52-407), F_1	16.15	0.75771		
18	(52-407 CMS X 52-307), F_1	16.23	0.81592		
19	[(52-307 X 52-407), F_1], F_2	15.83	1.14459	0.49850	0.44
20	[(52-307 CMS X 52-407), F_1 X 52-307], B_1	16.59	0.89034	0.24425	0.27
21	[(52-307 CMS X 52-407), F_1 X 52-407], B_1	15.53	0.75178	0.10569	0.14
22	GW 359-52R	14.84	1.59011	0.94402	0.59

segregating generations from 52-305 X 52-307 and 52-307 X 52-407. The successful 3-gene model is shown in Table 2. The obtained means and total genetic variances were not significantly different from the theoretical means and total genetic variances for any of the segregating generations of 52-305 X 52-407, neither were the theoretic frequency distributions based on this model different from the obtained frequency distributions for the segregating generations. In Table 2 plus (+) signs refer to capital B or C genes and the minus (-) signs refer to lower case b or c genes. The genotype aa++++ would be aaBBCC and aa++-- would be aaBBcc or aabbCC.

Table 2. Genetic model to explain obtained data of segregating generations from 52-305 X 52-407. Phenotypic values are added to the base value of aabbcc (52-407) 14.74%.

Genotypes and phenotypic values		
aa++++ = 2.56	Aa++++ = 2.86	AA++++ = 3.15
aa+++- = 1.56	Aa+++- = 2.06	AA+++- = 2.86
aa++-- = 0.96	Aa++-- = 1.56	AA++-- = 2.56
aa+-+- = 1.06	Aa+-+- = 2.26	AA+-+- = 2.06
aa+--- = 0.86	Aa+--- = 1.06	AA+--- = 0.96
aa---- = 0.00	Aa---- = 0.86	AA---- = 0.96

The mean of aa---- was 14.74% (which was the obtained mean of 52-407). Thus the mean of aa++-- would be 14.74 + 0.96 or 15.70%. This model was somewhat complicated in that phenotypic dominance was occurring at all loci but to different degrees depending on the combination of genes in a genotype. Epistasis was, therefore, also involved. For example a gene in the heterozygous state (+-) paired with two genes in the homozygous state (++--) actually caused a decrease in sucrose. For example Aa+--- gives 15.80% sucrose while AA+--- gives only 15.70% sucrose. 52-305 was described in the model as having all three genes (AABBCC) different from 52-407 (aabbcc). Hence it was logical that some part of this model should also explain the genetic difference between 52-305 and 52-307 and between 52-307 and 52-407. This was not the case and to increase the gene number of the model proposed to explain the difference of 52-305 and 52-407 from 52-307 was not practical. The genotype of 52-305 in Table 2 was AABBCC and 52-407 was aabbcc. Since 1, 2, and 3-gene models did not explain the difference between 52-307 and 52-407, and 1, 2, and 3-gene models did not explain the difference between 52-305 and 52-307, 52-307 could not have the same genotype as 52-305 (AABBCC), although their means were relatively similar. It was also obvious that 52-307 could not have the same genotype as 52-407 (aabbcc). Thus the only way 3-gene models could have described the variability in segregating generations of this three way diallel was to have introduced a factor of expressivity or penetrance which would then have

allowed AABBCC to be expressed in 52-307 when crossed with 52-305, yet would not have allowed AABBCC to be expressed in the same manner when 52-307 was crossed with 52-407. Thus it would seem that some cause, either genetic or environmental, was obscuring a discrete breakdown of the obtained data for the segregating generations from crosses of 52-305 X 52-307 and 52-307 X 52-407. The evidence indicated that interaction of several genes with minor effects could have caused the above problem. Other causes such as pleiotropy of genes effecting both sucrose content and root yield may have also caused the difficulty. These will be discussed later.

Weight of Root

The means and variances for root weight are listed in Table 3. The same general procedure was followed in developing and testing genetic models for root weight. Gene models involving up to four genes were tested and none adequately explained the obtained weight data. Dominance, epistasis, and different magnitudes of gene effects were used without success. Either the characters were conditioned by more than four genes, interaction of minor genes was accumulative, or pleiotropy was present. It was not possible to test 5-gene models due to the population size of only 440. Total genetic variances were estimated by using the regression of variances on means of nonsegregating populations to estimate environmental variances.

Interrelations of Sucrose Content and Root Weight

The difficulty of developing genetic models for sucrose content and root weight could be due to several causes as already noted. The most important of which might be insufficient number of genes in the model and/or pleiotropy. Pleiotropy is simply the process whereby a gene affects two or more characters so that if the gene is segregating it causes simultaneous variation in the characters it affects, but until methods are developed for partitioning bivariate genetic data the presence and degree of pleiotropic effect will be difficult to determine with certainty. The degree of correlation arising from pleiotropy expresses the extent to which characters are influenced by the same genes but the correlation of two characters results from the inseparable effect of pleiotropy and environment. It is clearly evident that any characters entirely dependent on the same physiological genetic process can not be recombined. Previous studies, where it was possible to partition the total correlation of sucrose and weight into environmental and genetic components, indicated that when the total correlation was negative the majority of this negative correlation was contributed by environment. Instances of negative, zero, and even positive genetic correlations of sucrose and weight have been observed. It should be pointed out that this was total genetic correlation and might include effects of both additive and nonadditive genetic relationships. Correlations involving only additive action of linked or pleiotropic genes have never been developed in sugarbeets.

General indications from the partitioning analysis of this study and from partitioned genetic correlations in other studies suggests that pleiotropy between sucrose and weight is probably present and usually

Table 3. Populations, means, total within plot variances, and total genetic variances for root weight.

Pop. No.	Population	Mean (Kg/root)	Total within plot variance	Total genetic variance	Broad sense heritability (h^2)
1	52-305 CMS	0.2772	0.00839		
2	52-305	0.2843	0.00845		
3	52-407 CMS	0.3576	0.01585		
4	52-407	0.3395	0.01494		
5	52-307 CMS	0.4227	0.02100		
6	52-307	0.3847	0.01121		
7	(52-305 CMS X 52-407), F_1	0.5405	0.03882		
8	(52-407 CMS X 52-305), F_1	0.5470	0.03949		
9	[(52-305 X 52-407), F_1], F_2	0.4172	0.03527	0.01369	0.39
10	[(52-305 CMS X 52-407), F_1 X 52-305], B_1	0.4174	0.03648	0.01488	0.41
11	[(52-305 CMS X 52-407), F_1 X 52-407], B_1	0.4642	0.04071	0.01422	0.35
12	(52-305 CMS X 52-307), F_1	0.5788	0.03278		
13	(52-307 CMS X 52-305), F_1	0.5497	0.03516		
14	[(52-305 X 52-307), F_1], F_2	0.4516	0.03074	0.00557	0.18
15	[(52-305 CMS X 52-307), F_1 X 52-305], B_1	0.4348	0.03172	0.00830	0.26
16	[(52-305 CMS X 52-307), F_1 X 52-307], B_1	0.4547	0.03711	0.01160	0.31
17	(52-307 CMS X 52-407), F_1	0.6292	0.04321		
18	(52-407 CMS X 52-307), F_1	0.5409	0.03606		
19	[(52-307 X 52-407), F_1], F_2	0.4567	0.02693	0.00122	0.05
20	[(52-307 CMS X 52-407), F_1 X 52-307], B_1	0.4686	0.02623	0.0	0.0
21	[(52-307 CMS X 52-407), F_1 X 52-407], B_1	0.4549	0.02952	0.00400	0.14
22	GW 359-52R	0.5487	0.08457	0.04925	0.58

negative although not prohibitively strong. In other words negative pleiotropic effect for weight and sucrose would not appear to preclude the development of genotypes high for both characters. Certain genotypes, which at least partially accomplish this, appear to be present in the species.

Biochemical Considerations of Sucrose and Weight

The discussion of some known biochemical pathways in relation to sucrose and root weight may shed some light on the questions of gene action and possible relationships between the characters, both environmental and pleitropic. It is not entirely realistic to attempt to develop models with a given number of genes involved in sucrose production, since it is in fact the enzymes and the biochemical processes in the plant that determine sucrose production and/or its accumulation. We know that these biochemical systems are intricately interrelated and separable and classifiable genetically only when the genes have gross phenotypic effects. Table 4 shows the general diagram of some known pathways in relation to biochemical reactions leading to synthesis of sucrose and metabolites used in the development and structure of cellular material. The enzymes known to be involved with the pathways in the diagram are listed and correspond to the numbers beside the path arrows. The diagram in Table 4 shows that a set of enzymes (genes) for sucrose would also be representing at least part of the gene set involved with cell wall structure and presumably weight of root since both characters depend on the same metabolites resulting from the enzymes listed in the table. Now if there were competition of enzymes for some limited amount of essential metabolites then plus genes for weight could override some or all genes for sucrose synthesis. This competition could be for uridine diphosphoglucose (UDPG) or an increase in the activity of invertase to meet the need of more carbon for cell wall constituents (cellulose, non-cellulosic polysaccharides, hemicelluloses and pectins). Increasing nitrogen for example would then logically increase the efficiency of the plus genes for weight, either by a direct use of precursors of sucrose production (such as UDPG or G-1-P) or indirectly by catabolizing sucrose. Evolution has caused organisms to be necessarily efficient, so the former is probably more nearly correct. Thus we would have a pleiotropic set of genes for the two characters whose pleiotropic effect was enhanced by increasing nitrogen. Conversely, if the characters were in fact independent of each other, there has to be some other factor which was causing the negative total and genotypic correlations between the characters. Also if they are independent there could not be any limiting amounts of metabolites even if both characters use the same metabolites (the latter is almost imperative from present biochemical knowledge).

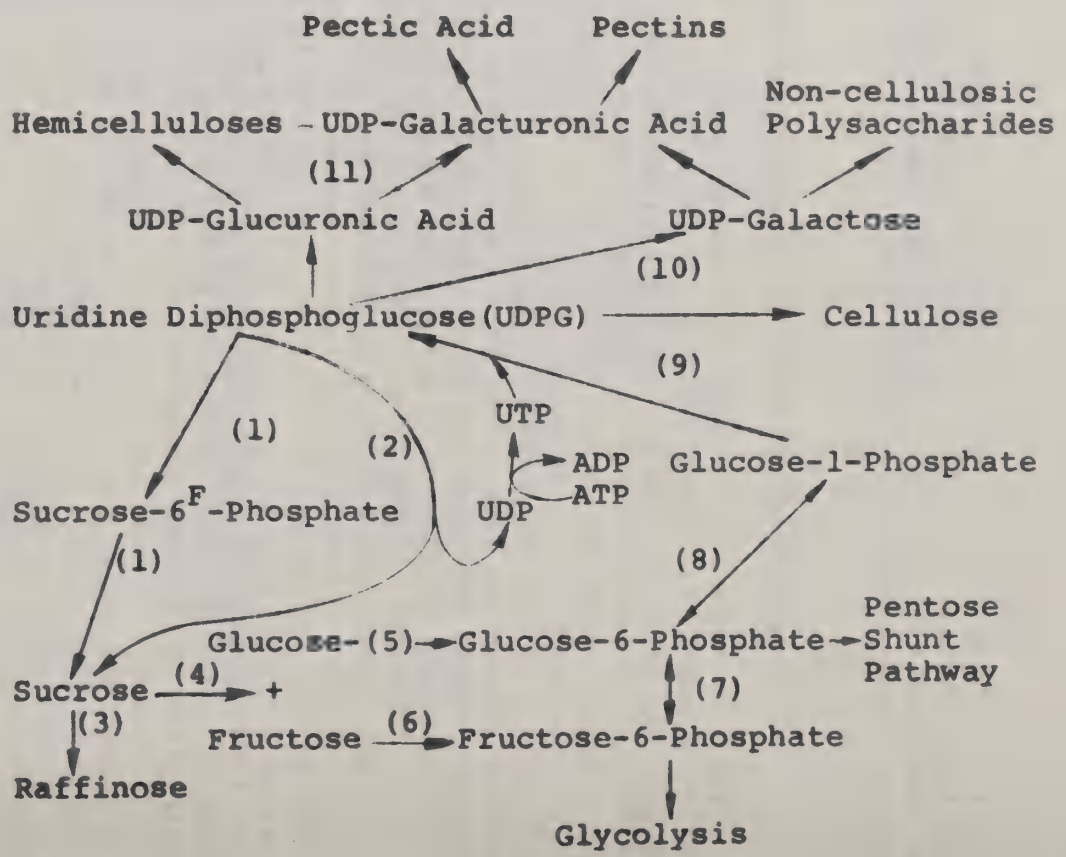
Table 4 has several enzymes listed which could be produced by genes affecting the data of this study. UDPG has been shown to be present in all sections of the sugarbeet plant, and it has been suggested that sucrose may be synthesized and UDPG regenerated in the root by the overall reaction

Table 4. General metabolic pathways involved with weight and sucrose in sugarbeet roots and the corresponding enzymes listed for the different biochemical paths.

List of Enzymes

1. Sucrose phosphate synthetase
2. Sucrose synthetase
3. Nucleotide diphosphogalactase
4. Invertase
5. Hexokinase
6. Fructokinase
7. Phosphohexoisomerase
8. Phosphoglucomutase
9. UDP-glucose pyrophosphorylase
10. UDP-D-galactose-4-epimerase
11. UDP-D-galacturonic acid-4-epimerase

UDP = Uridine diphosphate
UTP = Uridine triphosphate
ADP = Adenosine diphosphate
ATP = Adenosine triphosphate



$$ATP + UDP \rightarrow UTP + ADP \quad (A)$$

$$UTP + G\text{-}1\text{-}P \rightarrow UDPG + P\text{-}P \quad (B)$$

$$Fructose + UDPG \rightarrow Sucrose + UDP \quad (C)$$

$$Fructose + G\text{-}1\text{-}P + ATP \rightarrow Sucrose + ADP + P\text{-}P \quad (D)$$

Enzymes capable of effecting reactions (A), (B), and (C) are demonstrably present in the root and, in summation, the synthesis requires only a source of fructose and ATP, which are readily available, and glucose-1-phosphate. The root also contains phosphoglucomutase and glucose-6-phosphate, which can provide a source of glucose-1-phosphate. It, therefore, appears that a complete mechanism for sucrose synthesis occurs in the sugarbeet root.

Why there are two enzymes for sucrose synthesis (1 and 2 in Table 4) is not understood, but enzyme 2 has an equilibrium constant (Keg.) of approximately 8, whereas enzyme 1 has a Keg. of 32.50 in sugarbeet. This would indicate that the reaction catalyzed by enzyme 2 could easily be reversed if large amounts of sucrose were being transported down the phloem. This enzyme likely is not produced by a major gene. Enzyme 1, however, would be nearly irreversible and is probably produced by a major gene in relation to sucrose synthesis. Since there is really no information in sugarbeet as to the quantity and kinetic relationship of the above enzymes it is difficult to assign values of effect to different genes. Until this is done in populations with known differences of sucrose production it will be impractical to connect a genetic model which fits obtained data with the biochemistry of sucrose synthesis.

One thought comes to mind here as to how nitrogen may cause increased sensitivity of hybrid genotypes with respect to weight. There is evidence that many enzymes have a quaternary structure (more then one polypeptide chain) and that these can be separated easily without complete loss of function; accept for this purpose the one gene one enzyme hypothesis. Then if there is only one or two loci and several different possible alleles at each locus, the reaction or activity of enzymes could conceivably even be reversed by addition of subunits in the nature of polypeptide chains which are either more or less efficient in their reactions or may have different equilibrium constants. Nitrogen could then possibly act almost like a genetic allele by causing enzyme subunit changes on peptide chains of enzymes conditioning root weight.

It has been demonstrated in the lower organisms that basically genetics is nothing but biochemistry. By extrapolation we can say the same thing for the higher organism sugarbeet. So even though in this study we started out to try to genetically define sucrose and root weight, this definition could only have resulted from a rather simple genetic system all with major effects. This is certainly possible but if there are very many genes involved in sucrose synthesis and root weight it is not too probable. If it were possible to identify two genotypes which were isogenic except for one major factor, hence one enzyme, for sucrose synthesis then it should be possible to identify the enzyme in question and make a first step in higher organisms toward direct connection of genes

and enzymes. Heterosis which is a known fact in sugarbeets has not been mentioned in this study but was none the less present in the genetic model, for instance, in Table 2. It was also present in the case of root weight. Heterosis due to the accumulation of dominant factors was present to one degree or another in the genetic models tested and it also could be present in the enzyme system diagramed in Table 4.

Acknowledgment

Portions of this report are based on work reported in the Ph. D. dissertation of Robert W. Pylman, the research having been done while he was a Geneticist with Sugarbeet Investigations, CR, ARS, USDA at Fort Collins, Colorado.

Summary

The primary objective of this experiment was to study the inheritance of sucrose content and root weight in a diallel set of three inbred sugarbeets with the hope of finding a one or two gene difference between two of the inbreds. From the three inbred parents, three F_1's and their reciprocals were developed as well as the F_2's and B_1's to both parents for all three crosses. Powers' partitioning method of genetic analysis was applied to the individual plant data for both sucrose and weight. Genetic differences among the three inbreds were shown to be rather complex for sucrose content. There almost certainly were more than three genetic factors with major effect conditioning sucrose content in all three possible crosses, even though one 3-gene model was developed which adequately described the variation in the segregating generations of one cross. The inheritance of root weight appeared to be even more complex than that of sucrose content. Dominance of varying degrees was expressed for both higher sucrose and root weight. Epistasis was most likely also affecting both characters. Also pleiotropy, usually negative, or possibly linkage (most likely pleiotropy) was very likely to be affecting these two characters but not to the complete preclusion of simultaneous improvement of both characters. Consideration of the biochemical pathways involved in the synthesis of sucrose and cell structural compounds indicate that these syntheses are intricately interrelated and are probably separable and classifiable only when the conditioning genes (enzymes) have gross effects. Since certain synthesized metabolites are almost certainly limiting, the competition of enzymes for essential metabolites would mean that pleiotropy must be a factor which can in turn be modified by environmental factors such as available nitrogen. So based on the one gene one enzyme hypothesis we found that among the three inbreds there were none with one or two major enzyme differences for sucrose content or root weight. Such a difference would have allowed us to attempt to identify the particular enzyme difference and may have been a first step toward direct connection of genes and enzymes for sucrose synthesis or root size in sugarbeet. In this respect the study was unsuccessful. However, such limited genetic differences must be possible even though this study indicated that single gene differences may occur very infrequently due to the probable involvement of several genes for both sucrose and weight.

GENE ANALYSIS BY THE PARTITIONING METHOD OF SOME CROSSES BETWEEN SUGARBEET AND FODDER BEET

The purpose of this study was to obtain fundamental information about the genetic control of sucrose percentage in sugarbeet and fodder beet by the estimation of gene number, relative magnitude of gene effects, and type of gene action. Application of such information could be important from the standpoint of both genetics and practical plant breeding. Genetic information is useful to the development of more desirable economic types, especially since the ease with which gene combinations conditioning more desirable types can be brought together in one individual depends on the organization of the gene systems available to the breeder.

Recent studies conducted with inbred lines and their F_1 hybrids have provided evidence which demonstrated the existance of dominance and heterosis for sucrose content in sugarbeet. Another area of recurring interest has been the great yield potential of the fodder beet in respect to hybridization of fodder and sugarbeet types, but as of yet, little real yield advantage has been transferred. The demonstration of heterosis has added impetus to the development of hybrid commercial sugarbeet varieties, and the absence of information about the genetic control of sucrose has been a handicap to improvement of sugar yield in the past. The present work is more-or-less a pioneering study intended to gather basic information on genetic control of sucrose synthesis and accumulation which could lead to increased sucrose content without the normal repression of root weight.

The genetic studies of quantitative characters such as sucrose percentage require much more refined statistical methods than those used for qualitative characters with discontinuous variation. Advances made in the study of quantitative characters can generally be placed into two categories: (a) those dealing with variability and identification of its source, i.e., components of variance and diallel analysis, and (b) those extending qualitative methods to quantitative characters. Powers' partitioning method of genetic analysis falls into this second group and is credited by R. W. Allard as being the most advanced method using this approach.

In this study, which involved a sugarbeet parent, 52-305 CMS (cytoplasmic male sterile), a white fodder beet parent, Ovana, and their hybrids, a gene analysis was made using Powers' method of partitioning the variance and frequency distributions of the segregating populations. While this method has been used on data from tomatoes and barley, it has never been applied to sugarbeet data. Thus, the present study is the first to attempt such an analysis for sugarbeets.

The materials primarily involved in this study were the high sucrose sugarbeet inbred 52-305 CMS, the high root yield fodder beet Ovana, and their F_1, F_2, B_1, and B_2 progenies. Ovana was heterozygous for genes conditioning type O (nonrestorer genotypes). Hence all crosses with

52-305 CMS segregated for pollen sterility and fertility which facilitated the development of the backcross generations. It should be noted that Ovana was not completely homozygous for sucrose genes, but it was low in sucrose and was assumed to have a very different genetic complement for sucrose than the sugarbeet 52-305 CMS. Due to the presence of some variability for sucrose in Ovana some was also present in the F_1. This was not considered a serious deterent to using the partitioning method since no major genes for high sucrose appeared to exist in Ovana.

The experiment consisted of 12 populations grown in 40 replications with 480 individual plant determinations in each population and grown for one year in one location. To obtain the F_1 population, 52-305 CMS was used as the female parent and Ovana as the male. To produce the F_2 a random sample of F_1 progeny (both male sterile and male fertile) were allowed to interpollinate at random in a spatially isolated plot. Due to the presence of male sterile plants, pollination was not completely random, but it was assumed that the genes conditioning type O were not closely linked with any particular genes affecting sucrose and also that by this method there was less probability of causing a change in gene frequency (from F_1 to F_2) than had the male steriles been rogued. These plants were harvested separately and an equal quantity of seed from each F_1 plant was composited to provide the F_2 seed. Reciprocal backcrosses 1 and 2 were also included as well as B_1's open pollinated for one generation (OP_1).

Populations 52-305 CMS and 52-305 were included as parent material and also as nonsegregating populations to be used in estimating the environmental variance and distributions due to environment. The F_2 and the four backcross populations (B_1P_1, B_1P_2, B_2P_1, and B_2P_2) were used to test the genetic hypotheses. The more segregating related generations that can be included in a study, the less likely the acceptance of a false genetic hypothesis.

The partitioning method of genetic analysis is based on the fact that the frequency distribution of any segregating or heterogeneous population is composed of a number of genotypes and that individuals of each genotype fluctuate about a common mean. Hence a segregating population is composed of as many subgroups as there are genotypes, each with its own set of statistics (mean, frequency distribution, and variance). The partitioning method involves development of genetic models for the parents and the generation of these subgroup distributions in segregating populations. Tests for validity of the models are made by comparing the obtained and theoretical values for frequency distributions, genetic variances, and means.

Means, total variances, total genetic variances, and frequency distributions were calculated for each population and studied to establish the simplest possible genetic hypothesis for the inheritance of sucrose percentage. The components of variance(environmental and genetic) were estimated by using the inbred (52-305 CMS and 52-305) to estimate the environmental variance. The environmental variances were homogeneous.

Genetic variances were estimated by subtracting the environmental variance estimate from total within plot variances.

From an examination of the data in Table 1 it was apparent that there was a marked difference between the means and variances of the two parents. The F_1 mean of 11.89 ± 0.063 percent was significantly higher than the mid-parent mean which indicated that there was partial dominance present in the hybrid. The significantly higher F_2 mean (13.48 ± 0.083) compared to that of the F_1 (11.89 ± 0.063) showed that there was intrallelic (dominance) or interallelic (epistasis) interaction for certain genes conditioning sucrose content. The means and variances of the backcross populations follow the normal pattern of their parents. The estimated genetic variance was higher in backcrosses to Ovana due to the presence of some genetic variance in Ovana.

Frequency distributions of the parents were acceptably normal so data transformation was not considered. Some of the segregating populations were anormal but this could be expected since these distributions were a composite effect of both environmental and genetic variability. The more sensitive tests for normality using the third moment about the mean (skewness) and the fourth moment (kurtosis) showed that none of the populations were perfectly normal. However, for practical purposes, the chi square tests showed that environmental distribution was sufficiently near normal to allow the partitioning method to be used.

The preliminary estimate of the number of genes, as described by Leonard et al. (1), showed that sucrose percentage in the F_2 population was conditioned by two or more factor pairs. Further testing by the methods of Powers, where ratios of F_2/P_2 in percentage were calculated starting from the lower classes of the F_2 and P_2 respectively, indicated at least a 3-factor difference. A gradual rise in percentage values used for the estimation of the number of genes involved indicated that complete dominance was absent and that there was incomplete dominance or some degree of epistasis.

Having come to these conclusions, genetic models or hypotheses were developed and their validity was tested. To test the validity of a genetic model, the theoretical means and the theoretical genetic variances calculated for the segregating populations should not be significantly different from the obtained means and obtained genetic variances of the respective populations. The F_2 is a more discriminating segregating population than the backcross generations, but for any model to be accepted none of the obtained and theoretic statistics ($\bar{X}$, s^2, and frequency distributions) can be significantly different.

A 2-gene model was first tested in which P_1 (52-305 CMS) was designated as AABB and P_2 (Ovana) as aabb, gene A being completely dominant and gene B having no dominance. The gene magnitude of A = 1.35 percent and B = 3.66 percent were worked out from the obtained means of P_1, F_1, and P_2. The theoretic F_2 mean (11.5525) and theoretic F_2 genetic variance (7.0395) were significantly different from the obtained F_2 mean (13.4817) and genetic variance (2.1562). This model, therefore, was immediately rejected. It

Table 1. Means and their standard errors, total within-plot variances, estimated genetic variances, and heritability ratios for sucrose percentage. Estimated environmental variance = 0.64442.

No.	Population	Mean (%)	Total within-plot variance	Estimated genetic variance	Heritability ratio (h^2)
1	(P_1) 52-305 CMS	15.55±0.052	0.64891	---	---
2	(P_1) 52-305	15.55±0.058	0.63992	---	---
3	(P_2) Ovana	6.88±0.073	2.29794	1.65352	0.720
4	(F_1) 52-305 CMS X Ovana,F_1	11.89±0.063	1.30606	0.66164	0.507
5	(F_2) 52-305 CMS X Ovana,F_2	13.48±0.083	2.80063	2.15621	0.770
6	(B_1P_2) [(52-305 CMS X Ovana)F_1 X Ovana]B_1	9.22±0.080	2.68064	2.03622	0.760
7	(B_1P_1) [52-305 CMS X (52-305 CMS X Ovana)F_1]B_1	13.15±0.074	1.65625	1.01183	0.611
8	($B_1P_2OP_1$) [(52-305 CMS X Ovana)F_1 X Ovana]B_1OP_1	9.07±0.077	2.34792	1.70350	0.726
9	($B_1P_1OP_1$) [52-305 CMS X (52-305 CMS X Ovana)F_1]B_1OP_1	12.23±0.069	1.69256	1.04814	0.619
10	(B_2P_2) {[(52-305 CMS X Ovana)F_1 X Ovana]B_1 X Ovana}B_2	8.64±0.068	2.00197	1.35755	0.678
11	(B_2P_1) {52-305 CMS X [52-305 CMS X (52-305 CMS X Ovana)F_1]B_1}B_2	13.71±0.066	1.57643	0.93201	0.591
12	GW 359-52R	15.12±0.068	1.84495	1.20053	0.651

was apparent from the test of this 2-gene model and observations of the obtained means, genetic variances, and frequency distributions that two effective factor pairs could not explain the obtained results. Ten 3-gene models were then proposed and upon similar testing were also rejected. All evidence indicated that neither two or three effective factor-pairs, regardless of dominance, epistasis, or gene effect, could satisfy the conditions of the obtained results.

Testing of 4-gene models was the next logical step, since by increasing the number of gene pairs from 2 to 3 it was possible to reduce the theoretic F_2 genetic variance considerably. Twenty-six 4-gene models were developed using various parental genotypes with different gene magnitudes ranging from equal and additive effects to complete dominance and epistasis. When tested against the obtained statistics three of the models gave some hope of success. Their theoretic and obtained F_2 genetic variances were not significantly different, whereas their F_2 theoretic means were significantly lower than the obtained F_2 mean. Further testing was done of the B_1P_1 and B_1P_2 progenies. While some of the data showed close correspondence, a poor fit of the obtained and theoretic means for the F_2 and B_1P_1 and of the obtained and theoretic B_1P_2 genetic variances led to rejection of the models. In view of the overall results it was evident that none of the 4-gene models were appropriate.

Since it was apparent, with the same gene magnitude, that the higher the number of genes the lower was the genetic variance, 5-gene models were next proposed. However, again the primary difficulty arose in generating a model which would have an acceptable theoretic mean without at the same time having an unacceptably high genetic variance. Of the seven proposed 5-gene models, the one described in Table 2 most nearly described the obtained data. However, the F_2 theoretic genetic variance was still significantly different from the obtained genetic variance. So the genetic model in Table 2 did not account for all variability in the segregating generations. Considering genetic conditions already imposed on the 5-gene models, it appeared unlikely that any 5-gene model could satisfactorily describe the true genetic situation. It appeared to be a case of over five genes. However, with 480 plants per population the partitioning method is not sufficiently discriminatory to make an analysis of more than five genes worthwhile. Therefore it was decided to carry the best 5-gene model (Table 2) through a complete analysis.

The model in Table 2 proposed that all five of the gene pairs had equal and additive effects, except that there were certain epistatic interactions where the magnitude of the gene effect was altered. There was no clear explanation for some of these interactions, but in order to bring the obtained and theoretical means closer together, the imposition of such interactions was necessary. Theoretical values for means and total genetic variances were calculated for all five segregating generations. Theoretical frequency distributions were also calculated and compared with obtained distributions. Comparison of these obtained and theoretic values, Table 2, showed that these means were not different in any of the five segregating generations. Obtained and theoretic genetic variances were not

Table 2. Five-gene model for inheritance of sucrose percentage and the theoretic statistics resulting from its application to the five segregating populations; also included are the corresponding obtained means and total genetic variances.

Genetic model: All genes equal and additive except in the following special cases: (i) if 3 heterozygous + 1 homozygous recessive pairs, add 3.930; (ii) if 2 heterozygous + 1 homozygous recessive pairs, add 3.198; (iii) if 2 heterozygous + 2 homozygous recessive pairs, add 4.932; (iv) if 1 heterozygous + 1 homozygous recessive pairs, add 1.002; (v) if 1 heterozygous + 2 homozygous recessive pairs, add 2.004; (vi) if 1 heterozygous + 3 homozygous recessive pairs, add 3.006; (vii) no change in case of other genotypes.

Parental genotypes: P_1 = AABBCCDDEE
P_2 = aabbccddee

Gene magnitude: AA, BB, CC, DD, or EE = 3.110
Aa, Bb, Cc, Dd, or Ee = 2.378
aa, bb, cc, dd, or ee = 1.376

Pop.	Mean		Total genetic variance		Chi square P value of theo. & obt. distributions
	Theoretic	Obtained	Theoretic	Obtained	
F_2	13.39	13.48	4.8182	2.1562	<.01
B_1P_1	13.72	13.15	0.6698	1.0118	<.01
B_1P_2	9.38	9.22	1.2550	2.0362	.95 - .90
B_2P_1	14.33	13.71	0.5954	0.9320	<.01
B_2P_2	8.55	8.64	1.1156	1.3576	.70 - .50

different for B_2P_2 but were significantly different for the other four generations. Obtained and theoretic frequency distributions were not different for B_1P_2 and B_2P_2 but were different for F_2, B_1P_1, and B_2P_1. Hence even this best model was not even approximately correct and had to be rejected.

In the present case, since none of the proposed models up through 5-gene pairs satisfied the obtained conditions, the conclusion was drawn that sucrose percentage, in the F_2 and other segregating generations from a cross between the sugarbeet 52-305 CMS and the fodder beet Ovana, was conditioned by more than five gene pairs with some dominance and epistasis necessary. This conclusion was drawn from the results of the genetic models which involved epistasis at one or two loci. These gene models raised the means but did not lower the variance to within the limits of the obtained data. This could be expected if there were non-allelic genes present which could interact with other genes in different dominance situations.

It could not be determined from this analysis if useful genotypes might be recovered from the sugarbeet by fodder beet segregants. However there were no plants of the F_2, B_1P_1, $B_1P_1OP_1$, or B_2P_1 in the two highest distribution classes of the sugarbeet parent (P_1). This was among a total of 1920 random plants, so the negative relation of sucrose and root size may be more intense due to pleiotropy, linkage, or epistasis than within sugarbeet itself. Some selections based on phenotype and progeny performance (general combining ability) are being made in an attempt to discover the genetic and physiological limitations of recombining high sucrose content and root weight.

SUMMARY

Sugarbeet (P_1) and Ovana fodder beet (P_2) were crossed and various segregating generations were developed. P_1, P_2, F_1, F_2, B_1P_1, B_1P_2, $B_1P_1OP_1$, $B_1P_2OP_1$, B_2P_1, B_2P_2, and a commercial check were in a field study and 480 plants in each population were individually analysed for sucrose content. The purposes were to discover the number of major gene differences for sucrose between sugarbeet and fodder beet and to evaluate the possibility of recombining desirable genes from both sources. Powers' partitioning method of genetic analysis was used in an attempt to develop a genetic hypothesis which satisfactorily described the variability in the various segregating generations. Gene models of two through five genes with dominance of varying degrees and epistasis of many types were tested. None of the gene models gave theoretic means, genetic variances, and frequency distributions which were completely comparable with these obtained statistics in all segregating generations. It was concluded that sucrose, in this sugarbeet by fodder beet cross, was conditioned by more than five gene pairs with dominance and epistasis likely to be present. This makes the inheritance of sucrose quite complex from a breeding standpoint. Although a bivariate analysis of sucrose and root weight has not been completed it would appear that parental sucrose genotypes were not recovered in a random sample of 480 plants in each segregating

generation. At this point it would appear that there probably are genetic and physiological limitations on recombining genes for high sucrose and root weight per se but this does not mean that genotypes with high combining ability for both characters cannot be found. Research in both the theoretic and practical aspects are being continued.

ACKNOWLEDGMENT

Portions of this report are based on work reported in the Ph. D. dissertation of the late Dr. A. R. Mir, the research having been done while he was an AID participant with Sugarbeet Investigations, CR, ARS, USDA, at Fort Collins, Colorado.

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INHERITANCE OF A COMPOUND ASSOCIATED WITH CERCOSPORA LEAF SPOT RESISTANCE IN SUGARBEET

A phenolic compound (3-hydroxytyramine) present in sugarbeet leaves is known to be related to resistance to Cercospora beticola Sacc. (4). Oxidized 3-hydroxytyramine was found to be toxic to Cercospora beticola in pure culture (4). Kovacs (5) found that the low frequency of lesions on leaves of a resistant sugarbeet variety was correlated with the presence of a diffusible inhibitor on healthy leaves. Harrison et al. (2) found that fewer Cercospora spores germinated on the resistant leaves or in washings from resistant leaves. It has not been definitely established that this diffusible inhibitor is 3-hydroxytyramine or its oxidation products. There is some increase in the 3-hydroxytyramine content of leaves as a result of fungus infection (1). Also Harrison et al. (3) reported that 3-hydroxytyramine increased in response to artificial injury. The exact relationship of 3-hydroxytyramine and Cercospora resistance has not been established, nor has it been established that resistance might depend partly on the ability of the plant to provide some inhibitory compound upon injury or other stimulation rather than entirely on its original concentration. However, it appears that the inherent concentration of 3-hydroxytyramine may be important since correlations of 3-hydroxytyramine content with leaf spot resistance ratings show that most resistant varieties and genotypes, under both diseased and disease free conditions, contain more 3-hydroxytyramine than susceptible types (4, 6).

Presuming that the genes responsible for 3-hydroxytyramine content in noninfected plants were also responsible, to a large degree, for 3-hydroxytyramine content in infected plants, it was decided to attempt a genetic analysis of this character to determine the genetic differences between two inbred lines of sugarbeet. Powers' partitioning method of genetic analysis was used primarily. It is obvious that the more that is known about the genetics of a quantitative character, the more direct can be the approach to breeding or modification of the character. When the precise role of 3-hydroxytyramine in Cercospora resistance is established, information about the mode of inheritance of 3-hydroxytyramine may well be very important in selecting and breeding for resistant genotypes.

The plant material used in this study involved two inbred lines of sugarbeet, 52-305 (relatively high in 3-hydroxytyramine and moderately resistant to leaf spot), and 52-407 (relatively low in 3-hydroxytyramine and leaf spot susceptible). 52-305 was used both in the male fertile (MF) and cytoplasmic male sterile (CMS) forms. 52-305 and 52-407 were both long term inbreds; each had been inbred the equivalent of at least 10 generations of selfing. 52-305 CMS resulted from 6 generations of backcrossing a CMS source to 52-305. Also included were F_1, F_2, and first backcross generations to 52-305 (P_1) and 52-407 (P_2). Hence there were three segregating generations in the experiment (F_2, B_1P_1, and B_1P_2) and three nonsegregating generations (P_1, P_2, and F_1). The experimental design was a randomized complete block with 40 replications. Twenty-foot

single row plots were used with 22 inches between rows and about 10 inches between plants within a row. A relatively low vigor common competitor was used between plot rows. The experiment was grown under disease free conditions at the Colorado State University Agronomy Research Center in the summer of 1967. Leaves for 3-hydroxytyramine determinations were harvested on August 2 and 3, the approximate time of the growing season when, according to Harrison et al. (3), 3-hydroxytyramine content should be maximized. Six plants of each population in each replication were individually sampled. The four youngest fully expanded leaves on each plant were quick frozen at the field using dry ice and then stored at -29° C until analyzed in November, December, and January. 3-hydroxytyramine was measured as mg/100 g of frozen leaf. There were 240 individual plant determinations in each population.

The partitioning method of genetic analysis is a means of qualitating a quantitative character with the possibility then of determining something about the gene number and type of gene action conditioning the character. This approach to the genetic analysis of quantitative characters is not new; it was implied in Nilsson-Ehle's analysis of triplicate factors in wheat kernel color in 1911. It was further developed by several others but was brought to its most complicated form by Powers (8).

The six populations used in the study are listed in Table 1. It will be noted that inbred 52-305 MF was not included in the experiment. This male fertile equivalent of 52-305 CMS was used in developing the F_2 and backcross to 52-305 (B_1P_1). 52-305 MF and 52-407 MF were type O inbreds (non-restorers). Hence the backcross generations were easily developed by pollinating 52-305 CMS X 52-407,F_1 with 52-305 MF for B_1P_1 and with 52-407 for B_1P_2. In developing the F_2 generation the 52-305 MF X 52-407,F_1 hybrids were identifiable by a seedling marker gene. Twenty F_1 plants were interpollinated for production of the F_2 generation.

In using the partitioning method of genetic analysis it is necessary to develop a genetic hypothesis and from this hypothesis calculate theoretic means, genetic variances, and frequency distributions against which obtained means, genetic variances, and frequency distributions may be tested. Any preliminary information available from the data which might help in formulating a more accurate genetic hypothesis would be most useful. First of all, however, since approximate normality of environmental distributions is an assumption basic to the use of the partitioning method, as applied to this study, the obtained frequency distributions of the nonsegregating populations were tested. It was found that all obtained distributions, except 52-407 MF (P_2), had chi square P values of less than 0.01; they were not normally distributed. All populations were skewed to the left, significantly, and all had significant positive kurtosis. These tests of third and fourth moment statistics are considered to be quite sensitive tests for deviations from normality. Three scale changes were tested, namely, square root, 4th root, and $\log_{10}$ of 3-hydroxytyramine. The fourth root transformation was found to be quite acceptable; it removed all skewness and kurtosis from all populations except B_1P_2 which had negative kurtosis significant at the 5% level. This same transformation resulted in approximately normal distributions for all populations when comparing the calculated normal distributions

Table 1. Means, variances (total, total within plot, and genetic), and heritabilities for $\sqrt[4]{3\text{-hydroxytyramine}}$. Environmental variance estimated by regression equation $\hat{Y} = -0.606680 + 0.453159X - 0.063671X^2$.

Population	Mean	Total variance	Total w/in plot variance	Genetic variance	Heritability (h^2)
52-305 CMS (P_1)	3.005±0.035	0.2958	0.1988		
52-407 MF (P_2)	2.216±0.020	0.0964	0.0352		
F_1	2.719±0.031	0.2337	0.1673		
F_2	2.859±0.037	0.3363	0.2187	0.0502	0.23
B_1P_1	2.837±0.038	0.3441	0.2031	0.0366	0.18
B_1P_2	2.340±0.028	0.1901	0.1231	0.0180	0.15

with the obtained distributions by chi square tests. Replication variability was then adjusted out of the data using the methods described by Powers et al. (9), since estimates of environmental variance without replication variability were used to develop theoretic frequency distributions. The adjusted 4th root data had no significant third and fourth moment statistics. The chi square tests for normality gave an acceptably high P value (indicating normality) for all distributions except the F_2 where $0.02<P<0.05$. The adjusted 4th root data for P_1, P_2, and F_1 were normal which permitted use of the partitioning method. Genetic segregation in the F_2 is assumed to have caused its slight deviation from normality. However it is not necessary that the genetic variability be of any certain form.

Means and variances for the transformed data are shown in Table 1. The total within plot variances do not include variability due to replications. In order to estimate genetic variances necessary in the partitioning method an estimate of environmental variance was needed. A comparison of total within plot variances for the nonsegregating populations showed that they were not homogeneous, hence, their mean could not be used as an estimate of environmental variance. Expanding on methods of Powers (7), the quadratic regression equation of within plot variances on plot means for the three nonsegregating populations was developed. The multiple correlation coefficient was significant at the 1% level. Therefore from the quadratic regression equation, $\hat{Y} = -0.60668 + 0.453159X - 0.063671X^2$, developed from plot means and total within plot variances of 4th root 3-hydroxytyramine data for the three nonsegregating populations, the environmental variance for any mean within the range of the P_1 and P_2 means could be estimated. Using this equation and the F_2, B_1P_1, or B_1P_2 mean the environmental variances for these three segregating populations were estimated. These estimates were then subtracted from the total within plot variances to estimate the genetic variances for the three segregating populations. These estimates of genetic variance included both additive and nonadditive genetic variance and provided estimates of broad sense heritability (h^2) as well as a necessary comparison with theoretic genetic variances in the partitioning method. Heritabilities (h^2) for the F_2, B_1P_1, and B_1P_2 in Table 1 were quite low, ranging from 0.23 to 0.15. The low heritability in the F_2 (a product of two homozygous inbreds with quite different means) indicated that 3-hydroxytyramine content was characterised by high environmental variance. This detracts from the percision of inheritance studies, but in this study there was sufficient genetic variability to allow a genetic analysis by the partitioning method. In a genetic analysis such as this it is always best to initially select parents which are not greatly different with the likelihood that their gene differences for the characteristic of interest might be few, unless there is a specific interest in particular populations. P_1 and P_2 in this study had quite different 3-hydroxytyramine means in spite of the fact that P_1 was rated as only moderately resistant and P_2 as susceptible. However, even greater mean differences exist among inbreds which have been inventoried for 3-hydroxytyramine content. Choice of more similar parents may have resulted in inadequate genetic variance for reliable partitioning of the segregating populations.

Preliminary study of means, genetic variances, and frequency distributions indicated that the inheritance of 3-hydroxytyramine in this case was not simple. The mid parent value $(P_1 + P_2)/2$ was 2.610 while the F_1 was 2.719, indicating partial dominance for high 3-hydroxytyramine. Also $(F_1 + P_2)/2 = 2.468$ while $B_1P_2 = 2.340$, indicating partial dominance for low 3-hydroxytyramine. At the same time $(F_1 + P_1)/2 = 2.862$ while $B_1P_1 = 2.837$; this close comparison indicated no dominance. The F_2 was 2.859 which was higher than the F_1. This can most logically be accredited to epistasis; it probably did not result from dominance or linkage.

Preliminary consideration of number of major genes, or groups of closely linked genes which tend to act as a single gene, indicated that there was probably more than one gene involved.

In applying the partitioning method of genetic analysis the logical approach is to start with the simplest possible genetic hypothesis. In this case this would be one locus ($P_1 = AA$, $P_2 = aa$), no dominance, with each A allele adding 0.3945 to the P_2 mean of 2.216. A study of the F_2, B_1P_1, and B_1P_2 frequency distributions indicated that the P_1 and P_2 were genetically different at more than one locus with respect to 3-hydroxytyramine. However, development of this 1-gene model and calculation of theoretic means and genetic variances is shown in Table 2 for exemplary purposes. Since in Table 2 the F_2 theoretic and obtained means differ significantly as do the theoretic and obtained genetic variances, the genetic hypothesis must be rejected. The F_2 statistics are likely more critical than the backcrosses; however, the theoretic and obtained statistics for all these segregating populations must not differ significantly. Further the theoretic frequency distributions for the F_2, B_1P_1, and B_1P_2 can be calculated and compared with the obtained distributions. In the case of the 1-gene hypothesis in Table 2 there was no need to compare frequency distributions since the hypothesis had been rejected already on the basis of means and variances.

Other 1-gene models were tested. These included varying degrees of dominance. All such models were rejected. Genetic penetrance or expressivity were not useful modifications. It was concluded that the difference between P_1 and P_2 could not be explained by the genetic hypothesis of one effective factor difference. More complex genetic models were then tested. Models involving two and three loci with linkage of varying intensity, isodirectional and nonisodirectional effects, and various epistatic effects were all found to be inadequate to describe the obtained data. In general the greatest difficulty in developing a genetic model which described the obtained data was due to the rather high F_2 mean and low B_1P_2 mean. Models which included linkage tended to give genetic variances which were higher than obtained genetic variances. Linkage of any combination and intensity resulted in the model providing a poorer fit to the obtained means, genetic variances and frequency distributions.

Four-gene models were found to be inadequate without epistasis. A 4-gene model including complex epistatic combinations was found which satisfactorily described the obtained means and genetic variability. The 81 genotypes in the F_2 of this 4-gene model, with their frequencies and

Table 2. Theoretic means and genetic variances for $\sqrt[4]{3\text{-hydroxytyramine}}$. Genetic hypothesis: P_1 = AA, P_2 = aa, no dominance.

Pop.	Genotype	Genotype mean ($\bar{X}$)	Genotype frequency (F)	$\bar{X}^2$	
F_2	AA	3.0050	0.25	9.0300	
	Aa	2.6105	0.50	6.8147	
	aa	2.2160	0.25	4.9107	
	$\Sigma(\bar{X}F) = 2.6105$		theoretic mean = 2.61		**
	$\Sigma(\bar{X}^2F) = 6.8925$		obtained mean = 2.86		
	$CF=[\Sigma(\bar{X}F)]^2 = 6.8147$		theoretic genetic variance = 0.0778		**
	$\Sigma x^2/1 = 0.0778$		obtained genetic variance = 0.0502		
B_1P_1	AA	3.0050	0.50	9.0300	
	Aa	2.6105	0.50	6.8147	
	$\Sigma(\bar{X}F) = 2.8078$		theoretic mean = 2.81		
	$\Sigma(\bar{X}^2F) = 7.9223$		obtained mean = 2.84		
	$CF=[\Sigma(\bar{X}F)]^2 = 7.8836$		theoretic genetic variance = 0.0387		
	$\Sigma x^2/1 = 0.0387$		obtained genetic variance = 0.0366		
B_1P_2	Aa	2.6105	0.50	6.8147	
	aa	2.2160	0.50	4.9107	
	$\Sigma(\bar{X}F) = 2.4133$		theoretic mean = 2.41		**
	$\Sigma(\bar{X}^2F) = 5.8627$		obtained mean = 2.34		
	$CF=[\Sigma(\bar{X}F)]^2 = 5.8240$		theoretic genetic variance = 0.0387		*
	$\Sigma x^2/1 = 0.0387$		obtained genetic variance = 0.0180		

Table 3. Genotypes in the F_2 of a 4-gene model together with their means (based on the model) for $\sqrt[4]{3\text{-hydroxytyramine}}$ and expected frequencies.

Genotype	Mean	Frequency	Genotype	Mean	Frequency
AABBCCDD[1]	3.0050	0.00390625	AaBbCcDd[1,2]	2.7190	0.06250000
AABBCCDd[1]	3.0050	0.00781250	AaBbCcdd[2]	2.7190	0.03125000
AABBCCdd	2.9750	0.00390625	AaBbccDD	2.9500	0.01562500
AABBCcDD[1]	3.0050	0.00781250	AaBbccDd[2]	2.5250	0.03125000
AABBCcDd[1]	3.0050	0.01562500	AaBbccdd[2]	2.5250	0.01562500
AABBCcdd	2.9750	0.00781250	AabbCCDD	2.9600	0.00781250
AABBccDD	2.9700	0.00390625	AabbCCDd	2.9550	0.01562500
AABBccDd	2.9700	0.00781250	AabbCCdd	2.9550	0.00781250
AABBccdd	2.9650	0.00390625	AabbCcDD	2.9500	0.01562500
AABbCCDD[1]	3.0000	0.00781250	AabbCcDd[2]	2.4750	0.03125000
AABbCCDd[1]	3.0000	0.01562500	AabbCcdd[2]	2.4750	0.01562500
AABbCCdd	2.9700	0.00781250	AabbccDD	2.9500	0.00781250
AABbCcDD[1]	3.0000	0.01562500	AabbccDd[2]	2.3500	0.01562500
AABbCcDd[1]	3.0000	0.03125000	Aabbccdd[2]	2.3500	0.00781250
AABbCcdd	2.9700	0.01562500	aaBBCCDD	2.9600	0.00390625
AABbccDD	2.9650	0.00781250	aaBBCCDd	2.9600	0.00781250
AABbccDd	2.9650	0.01562500	aaBBCCdd	2.9550	0.00390625
AABbccdd	2.9600	0.00781250	aaBBCcDD	2.9450	0.00781250
AAbbCCDD	2.9700	0.00390625	aaBBCcDd	2.9450	0.01562500
AAbbCCDd	2.9700	0.00781250	aaBBCcdd	2.9400	0.00781250
AAbbCCdd	2.9650	0.00390625	aaBBccDD	2.9350	0.00390625
AAbbCcDD	2.9700	0.00781250	aaBBccDd	2.9350	0.00781250
AAbbCcDd	2.9700	0.01562500	aaBBccdd	2.9300	0.00390625
AAbbCcdd	2.9650	0.00781250	aaBbCCDD	2.9600	0.00781250
AAbbccDD	2.9600	0.00390625	aaBbCCDd	2.9550	0.01562500
AAbbccDd	2.9600	0.00781250	aaBbCCdd	2.9550	0.00781250
AAbbccdd	2.9550	0.00390625	aaBbCcDD	2.9500	0.01562500
AaBBCCDD[1]	2.9950	0.00781250	aaBbCcDd[2]	2.3440	0.03125000
AaBBCCDd[1]	2.9950	0.01562500	aaBbCcdd[2]	2.3440	0.01562500
AaBBCCdd	2.9700	0.00781250	aaBbccDD	2.9500	0.00781250
AaBBCcDD[1]	2.7000	0.01562500	aaBbccDd[2]	2.3100	0.01562500
AaBBCcDd[1]	2.7000	0.03125000	aaBbccdd[2]	2.3100	0.00781250
AaBBCcdd	2.9500	0.01562500	aabbCCDD	2.9350	0.00390625
AaBBccDD	2.9700	0.00781250	aabbCCDd	2.9000	0.00781250
AaBBccDd	2.9700	0.01562500	aabbCCdd	2.9000	0.00390625
AaBBccdd	2.9650	0.00781250	aabbCcDD	2.9500	0.00781250
AaBbCCDD[1]	2.5000	0.01562500	aabbCcDd[2]	2.3000	0.01562500
AaBbCCDd[1]	2.5000	0.03125000	aabbCcdd[2]	2.3000	0.00781250
AaBbCCdd	2.9500	0.01562500	aabbccDD	2.9500	0.00390625
AaBbCcDD[1]	2.7190	0.03125000	aabbccDd[2]	2.2160	0.00781250
			aabbccdd[2]	2.2160	0.00390625

1 = genotypes which also appear in B_1P_1
2 = genotypes which also appear in B_1P_2

means are listed in Table 3; the B_1P_1 and B_1P_2 genotypes are designated. The frequency of each of these backcross genotypes in the B_1P_1 and B_1P_2 was 0.0625. It can be noted in Table 3 that this 4-gene model included many complex interactions some of which are difficult to justify on the basis of known types of genetic interaction, although it is not genetically impossible that such interactions could exist. The obtained means and variances served as guides in specifying the interactions; hence the model was "made to fit" the obtained data. However 2- and 3-gene models could not be made to fit regardless of the number and type of interactions injected into the model. Table 4 lists the obtained and theoretic means and genetic variances developed from the genetic model in Table 3. It also shows the goodness-of-fit chi square P values for obtained and theoretic frequency distributions. The means, genetic variances, and frequency distributions calculated from the 4-gene model in Table 3 were not significantly different than the obtained statistics of the F_2, B_1P_1, and B_1P_2. Therefore the 4-gene model in Table 3 was adequate to describe the obtained results of the three segregating populations.

Table 4. Comparison of $\sqrt[4]{\text{3-hydroxytyramine}}$ obtained and theoretic means, genetic variances, and frequency distributions for the F_2, B_1P_1, and B_1P_2 (theoretic values based on 4-gene model in Table 3).

Pop.	Mean		Genetic variance		Freq. dist. chi square P values
	Theoretic	Obtained	Theoretic	Obtained	
F_2	2.77	2.86	0.059	0.050	$0.05<P<0.10$
B_1P_1	2.87	2.84	0.037	0.037	$0.80<P<0.90$
B_1P_2	2.41	2.34	0.023	0.018	$0.50<P<0.70$

99% confidence intervals on obtained means:

F_2 $2.77 \leq \overline{X} \leq 2.95$

B_1P_1 $2.75 \leq \overline{X} \leq 2.92$

B_1P_2 $2.28 \leq \overline{X} \leq 2.41$

In our opinion the genetic results from this partitioning method of genetic analysis are valid. Using this analysis method it was impossible to find any model with less than four genes which fit the obtained F_2, B_1P_1, and B_1P_2 data regardless of dominance, distribution of dominant genes among parents, linkage, penetrance, and epistasis included in the model. Hence it was concluded that the F_2, B_1P_1, and B_1P_2 generations were segregating for four or more effective genetic factors. We consider it probable that more than four were involved because of the complex

interactions necessary to make the 4-gene model describe the obtained data. This means that 3-hydroxytyramine in this case was relatively complex in its inheritance. This does not exclude the possibility that it may be conditioned by fewer genes in other cases. However, this would likely require major genetic factors not present in P_1 or P_2 of this study. The number of individuals in each population (240) was not large enough to permit accurate testing of genetic models with more than four genes.

Other methods of estimating gene number have been developed but the necessary assumptions are extremely limiting; 1) isogenic parents, 2) genes with large effect all in one parent, 3) equal effects of all genes with no dominance or epistasis, and 4) no linkage. Violation of assumptions results in the estimated gene number being smaller than the actual number. In our case all the assumptions were violated. The gene number was estimated as 1.51 by Castle's formula. Hence two genes is a minimal estimate of gene number conditioning 3-hydroxytyramine in this study. This supports the estimate of four or more genes using the partitioning method, but it provides little useful information by itself.

This study is part of a general investigation of the biochemical nature of Cercospora leaf spot resistance in sugarbeet. Under disease conditions mass selection combined with mother-line breeding, inbreeding, and formation of synthetic varieties and hybrids has resulted in a level of resistance which is adequate for marginal leaf spot areas but inadequate for complete protection in primary leaf spot environments. Identification of resistant genotypes has been difficult. It is possible that information on the biochemical basis of leaf spot resistance may lead to methods of accurately identifying and isolating resistant genotypes, preferably under disease free conditions, which can then be incorporated or transferred into commercial varieties and hybrids.

The two parental inbreds in this study are of no direct interest in breeding for leaf spot resistance and there is no way of knowing how genetically typical they are with respect to 3-hydroxytyramine content. So it is not logical to conclude things about all sugarbeets based on these two genotypes. But it is certain that 3-hydroxytyramine content is not simply inherited throughout the species. If 3-hydroxytyramine content becomes important in evaluation of leaf spot resistance its inheritance in adaptive germ plasm probably will be complex, making selection and breeding for 3-hydroxytyramine content a difficult project.

SUMMARY

A phenolic compound (3-hydroxytyramine) in sugarbeet is quantitatively related in some way to Cercospora leaf spot resistance (the exact relationship has not yet been established). Anticipating 3-hydroxytyramine content to be of interest in breeding for higher levels of leaf spot resistance, a limited study of its inheritance was conducted. From a high and a low 3-hydroxytyramine inbred, the F_1, F_2, B_1P_1, and B_1P_2 were developed. The partitioning method of genetic analysis was applied to the data. To meet assumptions the data were transformed to fourth root and adjusted to remove replication variability. Genetic models

involving different numbers of genes, varying additive gene effects, different degrees of dominance, epistasis, and linkage were tested in an attempt to explain the obtained F_2 and B_1 data. The quantity of 3-hydroxytyramine in this case appeared to be conditioned by four or more genes. The 4-gene model which satisfactorily described the obtained means, genetic variability, and frequency distributions was isodirectional and included additive, partial dominance, and epistatic effects. Some of the interactions were complex and a few were difficult to justify on the basis of common types of genetic interaction. It is likely that 3-hydroxytyramine was conditioned by more than four genes with partial dominance but somewhat less complex interactions than were present in our 4-gene model. Population size (240) limited the analysis to 4-gene models. If the two inbreds in this study are typical of genotypes in the species, selection and breeding for 3-hydroxytyramine content will likely be difficult due to multiple factors, dominance, and complex interactions.

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STUDY OF BIOCHEMICAL NATURE OF CERCOSPORA RESISTANCE

Introduction

This is a cooperative study with Professor Merle Payne of the Colorado State University Chemistry Department.

The objective of this experiment is to make a study of the relationship of various chemical components of sugarbeet leaves to Cercospora leaf spot resistance and their interrelationship with one another. Phenolic compounds, oxidative enzymes, and free amino acids are the principle components being studied.

That phenolic compounds play a role in disease resistance has been recognized for many years, but it is not known why their presence is more effective in some varieties of sugarbeets, for example, than in others. The principle phenolic compound found in sugarbeet leaves is 3-hydroxytyramine (2, 3). The 3-hydroxytyramine content of leaves of resistant varieties of sugarbeets is usually higher than in leaves of susceptible varieties (4, 5) but sometimes a rather high amount of 3-hydroxytyramine is also found in the leaves of some susceptible varieties. If the phenolic compounds are effective against disease resistance, what existing conditions make them more effective in one species than in another species when it exists in almost the same quantity in each? One theory is that its effectiveness may depend upon the oxidative enzymes present. A study made by Harrison et al. (3) showed that 3-hydroxytyramine, when oxidized, is toxic to Cercospora beticola grown in pure culture. Previous studies have also been made on the possible role of the naturally occurring polyphenoloxidase enzyme which is capable of oxidizing the 3-hydroxytyramine (4, 5). This experiment is set up for a more sophisticated study of the oxidative enzymes which are present in the sugarbeet leaves.

Free amino acids play a major role in the formation of plant phenols. Some believe that the effectiveness of the phenolic compounds in disease resistance may depend upon a delicate balance between the concentration of the phenolics and that of amino acid nitrogen.

Because of the possibility that these components may be major factors in disease resistance, and especially in Cercospora leaf spot resistance, this study was undertaken.

Materials and Methods

Nine populations of sugarbeets were chosen which offered a wide range selection in leaf spot susceptible and resistant varieties. Identical plantings were made on May 2, 1968, at Mr. John Gaskill's disease nursery and the Colorado State University Agronomy Research Center, both at Fort Collins, Colorado.

The populations selected and their description is as follows:

	Population	Remarks
1.	US 201	Highly leaf spot resistant, heterogeneous
2.	GWI-29	Leaf spot resistant, inbred
3.	SP 5822-0	Highly leaf spot resistant, heterogeneous
4.	GW 359-52R	Moderately leaf spot resistant, heterogeneous
5.	R and G Pioneer	Leaf spot susceptible, heterogeneous
6.	52-334	Leaf spot susceptible, inbred
7.	52-305CMS X 52-407, F_1	High 3-hydroxytyramine, homogeneous
8.	52-305CMS	High 3-hydroxytyramine, inbred
9.	52-407	Leaf spot susceptible, inbred

Four replications of each population were planted at each location in single row plots with common competitor rows separating the plots.

The plants at the Disease Nursery were inoculated with Cercospora beticola on July 5, 1968.

During the summer, fresh leaves were harvested on six different dates from the plants at the Disease Nursery and the Agronomy Research Center. Dates of harvest were determined by the progress of the disease on the inoculated plants. The leaf samples were harvested (4) at both locations on the same day and, as nearly as possible, at the same time of day. Five of the nine varieties were used for the selective summer study on oxidative enzymes, 3-hydroxytyramine, and free amino acids. All nine varieties were not used because some of the analyses are very time consuming. The varieties US 201, GWI-29, R and G Pioneer, and 52-334 were chosen for the enzyme study. Because of low yield on the 52-334, we substituted the variety 52-407 for it in the 3-hydroxytyramine and amino acid studies. Both varieties are classified as leaf spot susceptible inbreds. 52-334, in previous analyses, has always shown extremely low 3-hydroxytyramine content. R and G Pioneer is classified as leaf spot susceptible, heterogeneous, while US 201 is highly leaf spot resistant, heterogeneous, and GWI-29 is a leaf spot resistant inbred. Individual replications were analyzed for 3-hydroxytyramine, however, the replications were pooled for the oxidative enzyme and amino acid studies.

Sample harvest dates at both locations were as follows:

	Dates	Progress of Disease
1.	5 July	Just prior to inoculation at disease nursery
2.	22 July	First lesions showing on susceptible varieties
3.	31 July	First cycle lesions sporulating on susceptible varieties
4.	14 August	Second cycle lesions showing
5.	22 August	Second cycle lesions sporulating
6.	3 September	Infection peak

Leaf spot readings were made by Mr. John Gaskill on July 26 and August 19 at the Disease Nursery.

The leaves were analyzed immediately after harvest for 3-hydroxytyramine by the method used by Harrison et al. (4). Samples for amino acid analyses were prepared immediately after harvest of the leaves. A 25 gram sample was cut transversely from the center section of the carefully stacked leaves, placed in 100 ml of 10% sulfosalicylic acid solution (W/V), and ground for 5 minutes on a Waring blendor. This process deproteinizes the sample as well as deactivating the enzymes. The ground sample was set aside until it separated into two layers. An aliquot was pipetted from the lower liquid layer, centrifuged at high speed for 5-10 minutes, after which the clear liquid was poured off and adjusted to a pH 2 with 40% NaOH. The sample was then frozen and stored until it could be analyzed on the amino acid analyzer. At the time of analysis, the sample was thawed and recentrifuged before one or one and one-half ml was placed on the analyzer. The quantitative amount of each amino acid appearing on the resulting chromatogram was calculated by comparing it to a standard analysis which had been run previously (in duplicate or triplicate) using Technicon's 18 amino acid standard solution. An internal standard (L-α-amino-β-quanidinopropionic acid) was used with the 18 amino acid standard runs, as well as with the sample runs, to check on any change in the sensitivity of the color producing reagents which are used during the analysis on the amino acid analyzer. Fresh root samples were prepared by the same method. 25 grams of the freshly rasped root sample were ground immediately in 100 ml of 10% sulfosalicylic acid, centrifuged, adjusted to a pH 2, and frozen until analysis. Thin juice samples required no additional preparation except that they were adjusted to a pH 2 with 6.0 N HCl before they were frozen for storage. The methods used for the oxidative enzyme determinations are modifications of the method given for polyphenoloxidase determination by Harrison et al. (4) with other analyses also being used in conjunction with these which will be given in detail when a publication on this experiment is presented.

On October 16, 1968 the roots were harvested at both locations on all nine populations and the thin juice was prepared by the method described by Carruthers and Oldfield (1). The thin juice will be analyzed for purity, amine nitrogen, nitrate nitrogen, betaine, total nitrogen, sodium, potassium, calcium, and chlorides on a plot basis for the quality study.

Conclusions

Chemical analysis is now underway on this study; consequently conclusions concerning the project cannot be given at this time.

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VARIETY AND FERTILIZER NITROGEN EFFECTS ON AMINO ACID CONTENT AND QUALITY OF SUGARBEET

The quantity of some individual amino acids was determined in sugarbeet of different genetic backgrounds and different nitrogen fertility levels. The relationships of impurity components with each other and with yield factors was determined to obtain new information about where efforts or quality improvements might be most effective.

The study consisted of laboratory and statistical analyses of 36 yield, quality, and leaf component characters for 12 genetic populations at three nitrogen fertility levels over 2 years. The data of both years and of four genotypes or varieties showed that all measurable amino acids in the thin juice (equivalent to factory second carbonation juice) increased with increasing available soil nitrogen to some maximum or plateau which is genotype dependent. Every amino acid was present in larger quantity in 1967 than in 1966, which might be explained by a year interaction or by residual nitrogen in the field. The most abundant amino acids in thin juice were glutamic acid and then aspartic acid, although glutamine, PCA, serine, and threonine may have been abundant but were not measurable. Other amino acids found in the root were glycine, alanine, valine, methionine, isoleucine, leucine, tyrosine, phenylalanine, lysine, histidine, tryptophan, arginine, proline, cystine, asparagine, and ornithine. Most of these latter amino acids were in only small or trace quantities. Glutamic and aspartic acid are the primary products of nitrogen assimilation even though their quantity is probably not a reliable indicator of nitrogen assimilation capacity due to the conversion of the amides to amino acids to some extent under the conditions of analysis. In the thin juice the relationships of individual amino acids with each other and with other characters were quite constant indicating a rather static nature of free amino acids in the root at harvest. This was not the case for leaf amino acids.

The differences in thin juice amino acids due to nitrogen treatment was generally greater than that due to population effect. The relationship of amino acids to increasing nitrogen fertilizer was nonlinear for all populations but not of the same form in all populations. Hence increasing nitrogen was relatively less detrimental to certain populations. This was evidenced in the study by one genotype which did not accumulate nitrogenous organic compounds at a very rapid rate but also its yield response was not satisfactory.

Total nitrogen in the thin juice was somewhat different. Total nitrogen content was considerably different between populations which represents the potential for developing genotypes with low total nitrogen along with other desirable characteristics. In previous work at this station two genotypes were reported which had low total nitrogen in the thin juice along with relatively high sucrose and purity.

Nitrate nitrogen (NO_3-N) in the thin juice accounted for about 6%

of the total nitrogen. It was more closely related to sucrose content, root yield, and thin juice sodium and potassium than was total nitrogen. Even though NO_3-N may not be a quantitatively important nitrogen compound it could serve as a quality indicator. Nitrate nitrogen in the thin juice seems to be of more importance than has been reported previously. It was apparent that the nitrogenous compounds make varying contributions to total nitrogen in the thin juice, dependent on the nitrogen status of the soil and on the genotype. There was a portion of the total nitrogen and amino nitrogen which remained unaccounted in the analysis of nitrogen compounds that was made.

Betaine in the thin juice was conditioned more by genotype than by nitrogen fertilizer treatment. This is encouraging from a breeding standpoint since it indicates that relatively low betaine genotypes in all nitrogen environments should be synthesizable.

Amino acids in the thin juice and in the fresh root had the same quantitative relationship. It appears that either root tissue or thin juice could be used to determine the relative quantity of free amino acids in beet roots at harvest. There were no useful or meaningful relationships of leaf amino acids with yield and quality characters. Quantity of leaf amino acids and root amino acids were not consistently related.

Amino nitrogen compounds as a class are among the most deleterious to juice quality. It appeared that amino nitrogen was generally a better determinant of root yield, sucrose, purity, and recoverable sugar than was thin juice total nitrogen or nitrate nitrogen. However it was still only weakly related to recoverable sucrose. Sodium and potassium increased in every population with increasing nitrogen fertilization but at different rates in different populations. Betaine was the one nitrogenous compound whose quantity was affected more by genotype than by nitrogen fertilization. Quantities of copper, cobalt, calcium, magnesium, iron, and nickel in the leaves at harvest appeared to be of little value in determining beet quality or sucrose yield.

EFFECT OF NITROGEN ON AMINO ACID CONTENT

Introduction

In a 1967 field experiment entitled "Variety and fertilizer nitrogen effects on amino acid content and quality of sugarbeet" a preliminary study was made on free amino acids in sugarbeet fresh leaf, fresh root, and thin juice samples. Quantitative determinations were also made for some other impurity components. Three populations with ten replications were used. Three nitrogen levels of 0, 125, and 250 pounds per acre were randomized within the replications. The results of this study are given earlier in this 1968 report. Generally, there was an increase in the amount of most of the amino acids present as the nitrogen level increased. There was, however, some difference due to genotypes.

This 1968 experiment was designed as a follow-up study on the amino acids in an attempt to learn the effect of nitrogen at high levels on individual amino acids and other impurity components. We hope to learn also at what nitrogen level the individual amino acids reach a maximum, if this maximum level varies with genotypes, and if the increase in amino acids occurs as a linear, quadratic, or as some other ratio. The trends in high nitrogen levels may provide information on amino acid interrelationships and on effect of genotype at commercial nitrogen levels.

Materials and Methods

The 1968 experiment was grown under irrigation at the Colorado State University Agronomy Center. A split plot design with single row plots separated by common competition rows was used with three populations, six replications, and five nitrogen levels. The nitrogen levels of 0, 125, 250, 375 and 500 pounds per acre were all preplant, broadcast and harrowed. Two extra competitor rows were used between nitrogen treatments.

The populations were as follows:

Population	Remarks
1. GW 359-52R	Standard
2. 52-305 CMS X 54-346,F_1	High purity
3. 52-407 CMS X GWI 81,F_1	Low purity

All samples were harvested on a plot basis. Fresh leaves were harvested October 9, 1968, just prior to the root harvest on October 15. Samples for amino acid analysis were prepared from the fresh leaves and fresh roots as soon after harvest of each as possible as described in the

paper "Study of Biochemical Nature of Cercospora Resistance" found earlier in this report. Thin juice was prepared by the Carruthers and Oldfield method and samples of thin juice were also prepared for amino acid analysis. All amino acid samples were frozen and stored until analysis could be made on the Technicon Amino Acid Analyzer at a later date. Fresh leaf samples were also dried to a constant weight, ground, and stored in a dessicator for later analyses for total nitrogen and nitrate nitrogen. Thin juice samples will also be analyzed for total nitrogen, nitrate nitrogen, amine nitrogen, betaine, some metallic ions, and chlorides.

Results

Since chemical analysis is now underway on the samples from this experiment, no results have as yet been obtained.

ADDITIONAL SURVEY STUDIES ON AMINO ACIDS IN SUGARBEET LEAVES

In the amino acid studies on fresh leaves of sugarbeets using our amino acid analyzer we have always prepared the samples from the same section of the leaves and as soon after harvest as possible. At each sampling, leaves were selected which were intermediate between the small young leaves and the largest old leaves which show some signs of senility. The leaves selected were not the largest leaves on the plant but were mature leaves. We normally choose four leaves from the same plant if we are making the analysis on a single plant basis. If the analysis is on a plot basis, the same number of leaves is chosen from each plant in the plot. The leaves are carefully stacked together and a transverse section is cut from the middle of the stacked leaves to obtain the weight of sample required. This sampling technique for leaves has been used also for our analysis for phenolic compounds and oxidative enzymes to obtain as uniform a sample as possible. This was done because previous analyses had shown that the quantitative amount of phenolic compounds and enzymes do vary in different sections of the leaf and also in the different aged leaves. Whether there is this same variation in amino acid content has not been determined and this is the reason for these two small survey studies. Samples were prepared during the summer of 1968 from fresh leaves harvested at the Colorado State University Agronomy Center. Four populations were used in each study.

For analysis for amino acid content in different aged leaves three different aged leaves were selected from each population. They were: (1) older leaves which showed slight signs of senility, (2) fully expanded leaves of the same age as the leaves we have used for previous studies of amino acids, and (3) small young leaves. The samples were prepared immediately after harvest by grinding the fresh leaf sample in 10% sulfosalicylic acid for five minutes. The sulfosalicylic acid is used for deproteinization.

The whole leaves were ground for this experiment in the ratio of 25 grams of fresh leaf sample to 100 ml of 10% sulfosalicylic acid solution which is the ratio normally used. The resulting slurry is set aside until two layers separate. An aliquot is pipetted from the lower liquid layer and centrifuged for 10 minutes. The clear liquid is poured off and adjusted to a pH 2 with 40% NaOH. The samples are stored frozen until the analyses can be made on the amino acid analyzer.

Samples using three sections of leaves were prepared by the same method. Leaves were selected of the same age as has been used for previous amino acid determinations, that is, mature fully expanded leaves which show no visible signs of senility. The leaves from each population were stacked carefully and three transverse sections were cut as follows: (1) the tip section, (2) the middle section which has been used for previous amino acid analyses, and (3) the base section.

Results

The above samples were frozen and will be analyzed as soon as possible. We can run only two samples a day on our amino acid analyzer so considerable time is required to perform all the analyses which we hope to make in relation to amino acids.

PREDICTING PERFORMANCE OF DOUBLE CROSS HYBRIDS IN SUGARBEET

Heterosis for higher root yield, sucrose, and purity have been amply demonstrated in sugarbeet. Heterosis is now being capitalized upon through the utilization of hybrids in sugarbeet. We are now at the point of using single cross hybrids, three way hybrids, and top cross hybrids and surely double cross hybrids will be used in the not too distant future. The top cross proved to be very valuable in the testing of inbred lines of corn and is now proving to be of great value in the testing of inbred lines of sugarbeet for combining ability. With its use it is possible to identify the more promising inbred lines for use in hybrids. After the more promising inbreds have been selected on the basis of high general combining ability it is necessary to identify the particular single, three way, or double cross hybrids that will produce the highest yields. The number of combinations of inbreds taken four at a time, to produce double crosses, increases rapidly with increase in the number of inbreds. Thus, ten inbreds can be combined to produce $\frac{N(N-1)}{2} = 45$ single crosses, and $\frac{3(N!)}{4!(N-4)!} = 630$ double crosses, excluding reciprocals. As the number of inbred lines increases it rapidly becomes impossible to test all possible double cross combinations. In corn it was found possible to predict the performance of double crosses from the performance of single crosses. Several different methods of making the required predictions were investigated and it was found that the most accurate estimate of the relative yield of a double cross could be made from the mean yield of its four nonparental single crosses. In sugarbeet the task of making all possible single crosses and double crosses is impossible until male sterility has been incorporated into many of the inbreds or various of the inbreds have the proper marker genes. The study we have conducted is a very preliminary one utilizing five different inbred lines, only two of which had cytoplasmic sterile equivalents and three of which had red hypocotyl or red root. Since certain of the inbreds were highly self fertile and flowering dates did not always coincide, considerable difficulty was encountered in getting even those hybrids which were possible within the limitations of the cytoplasmic male sterility and the marker genes present. Of the 10 possible single crosses from five inbred lines we were able to develop only seven and of the 15 possible double crosses we were able to develop only nine. We were able to develop all five top crosses. We had hoped to get all necessary populations for the following four predictors of double cross performance.

1. Mean of the four nonparental single crosses.
2. Mean of all six single crosses among the four parents involved in any double cross.
3. Mean of all single crosses in which any of the four double cross parents were involved.
4. Mean of the red beet top crosses of the four parents in any double cross.

Due to the absence of certain single crosses we were unable to develop all

these predictions, however, we did go ahead and use the predictions with the available single crosses that we had. For instance, for prediction number 1 we had all four nonparental single crosses in only one case (double cross 14). For the other eight double crosses we merely used the three, or even two, nonparental single crosses that we had. Instead of prediction number 2 we used, where available, the mean of the two parental single crosses and the two nonparental single crosses involving the female of the maternal single cross. For example (AxB)(CxD) would have been predicted from the mean of AxB, CxD, AxC, and AxD. For prediction number 3 there were either four or five single crosses available. For prediction number 4 all four necessary top crosses were present in each case.

Table 1 lists the means for root yield, sucrose, and purity of all populations in the study. Table 2 lists the nine double crosses in the study, their actual means for root yield, sucrose, and purity, and the four predicted values for these same characters. The number of single crosses available for each prediction is indicated in Table 2. Also included in Table 2 are the correlations of actual and predicted performances. This correlation gives the relationship between actual and predicted performance. This correlation should also indicate the best predictor among the four tested. In the case of root yield the best predictor was indicated to be number 1, performance of the available nonparental single crosses. In the case of sucrose the difference between the correlation coefficients was not as great, but again predictor number 1 did have the highest correlation, 0.87. In the case of purity the highest correlation occurred with prediction number 4 (0.63) and prediction number 3 (0.44) was second. The only significant correlations were for sucrose content which does detract from the value of the correlations made for root yield and purity. However, those correlations which were not significant still indicate the relative relationships even though it can not be demonstrated that the relationships are significantly different from zero.

The data of this very preliminary experiment indicate that the mean of the four nonparental single crosses may be the best predictor of double cross performance for root yield and possibly for sucrose content. Thus for a double cross (AxB)(CxD) the best prediction of its performance would come from the mean of AxC, AxD, BxC, and BxD. Since the degree of expression of heterosis is much greater for root yield then for sucrose or purity it would also be expected that the prediction of double cross performances would be most useful for yield and possibly also most accurate and consistent.

The results of this study are preliminary and should be used only as an indication of possible performance. An expanded study of this nature is planned for 1969 in which every effort will be made to obtain all necessary single crosses for the double crosses which are available.

Table 1. Means for plot weight, sucrose, and thin juice apparent purity of all populations in the study.

Population	Mean		
	Plot wt. (Kg)	Sucrose (%)	Purity (%)
1. 52-305 CMS X 34,F_1	4.172	16.781	92.219
2. 52-307 X 52-407,F_1	11.722	16.800	92.481
3. 52-307 X 54-346,F_1	16.193	17.306	93.806
4. 52-305 CMS X 52-307,F_1	13.610	16.775	92.538
5. 34 CMS X 52-407,F_1	17.109	15.500	91.331
7. 52-305 CMS X 52-407,F_1	16.081	16.225	90.912
9. 52-305 CMS X 54-346,F_1	13.147	16.812	93.738
10. (52-305 CMS X 34,F_1) X (52-307 X 52-407,F_1)	15.522	15.869	91.594
11. (52-305 CMS X 34,F_1) X (52-307 X 54-346,F_1)	15.253	16.375	92.362
13. (52-305 CMS X 52-307,F_1) X (34 X 54-346,F_1)	12.266	16.431	91.962
14. (52-305 CMS X 52-407,F_1) X (34 X 52-307,F_1)	14.688	16.275	92.394
15. (52-305 CMS X 52-407,F_1) X (34 X 54-346,F_1)	14.388	15.962	92.262
16. (52-305 CMS X 52-407,F_1) X (52-307 X 54-346,F_1)	14.344	16.275	93.069
17. (52-305 CMS X 54-346,F_1) X (34 X 52-307,F_1)	13.759	16.475	92.869
18. (52-305 CMS X 54-346,F_1) X (34 X 52-407,F_1)	13.994	16.019	91.894
19. (52-305 CMS X 54-346,F_1) X (52-307 X 52-407,F_1)	14.725	16.588	93.406
20. 52-305 CMS X Red Beet,F_1	13.101	12.887	86.781
21. 34 X Red Beet,F_1	23.370	12.569	85.412
22. 52-307 X Red Beet,F_1	19.099	13.238	88.188
23. 52-407 X Red Beet,F_1	23.127	12.306	85.425
24. 54-346 X Red Beet,F_1	13.588	14.375	88.675
25. GW 359-52R	16.366	16.181	91.300
26. GW Commercial Hybrid	15.709	15.556	91.238

Table 2. Comparison of actual and predicted performances of the nine double crosses.

Double cross	Yield (Kg per plot)					Sucrose (%)					Purity (%)				
		Prediction					Prediction					Prediction			
	Actual	1	2	3	4	Actual	1	2	3	4	Actual	1	2	3	4
10	15.52	15.60(3)[1/]	11.40(4)	12.54(5)	19.67	15.9	16.2	16.6	16.4	12.8	91.6	91.6	92.0	91.9	86.4
11	15.25	13.38(2)	11.78(4)	11.78(4)	17.29	16.4	16.8	16.9	16.9	13.3	92.4	93.1	93.1	93.1	87.3
13	12.27	11.17(3)	10.31(3)	11.78(4)	17.29	16.4	17.0	16.8	16.9	13.3	92.0	93.3	92.8	93.1	87.3
14	14.69	11.65(4)	11.29(3)	12.54(5)	19.68	16.3	16.5	16.6	16.4	12.8	92.4	92.1	91.9	91.9	86.4
15	14.39	11.48(3)	11.13(3)	12.63(4)	18.30	16.0	16.4	16.6	16.3	13.0	92.3	92.4	92.3	92.0	86.6
16	14.34	12.83(3)	14.76(4)	14.15(5)	17.23	16.3	16.8	16.8	16.8	13.2	93.1	92.9	92.7	92.7	87.3
17	13.76	11.32(3)	10.31(3)	11.78(4)	17.29	16.5	17.0	16.8	16.9	13.3	92.9	92.9	92.8	93.1	87.3
18	13.99	10.13(2)	12.63(4)	12.63(4)	18.30	16.0	16.5	16.3	16.3	13.0	91.9	91.6	92.0	92.0	86.6
19	14.72	15.29(3)	13.64(4)	14.15(5)	17.23	16.6	16.8	16.7	16.8	13.2	93.4	92.4	92.4	92.7	87.3
Correlation (r) of act. & predicted		0.65	0.32	0.28	0.44		0.87**	0.54	0.83**	0.68*		0.42	0.35	0.44	0.63

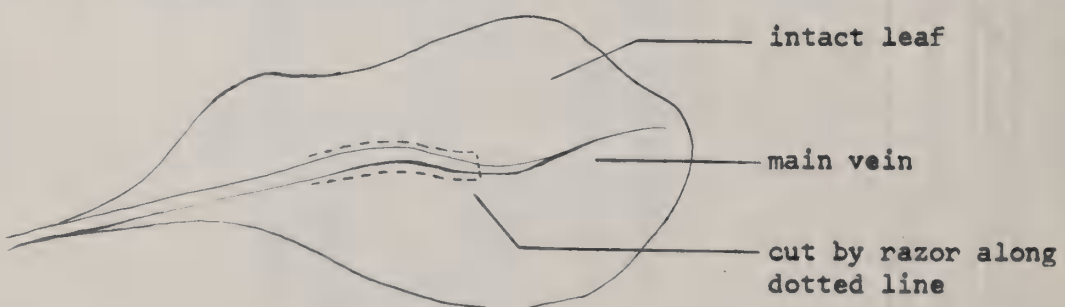
1/ Number of single crosses used in the prediction.

PRELIMINARY STUDIES TO INDUCE MALE STERILITY IN SUGARBEETS WITH AN ANIMAL SEX HORMONE (OESTRONE)

The advantages of male sterility in sugarbeets are well known for both breeding purposes and commercial seed production. Cytoplasmic and genetic male sterile lines of sugarbeets have been developed and used extensively. However, the mechanism of male sterility in sugarbeets is not completely understood. It appears that environment has a considerable effect on this sterility, as under different conditions conversion of some male sterile lines to at least partially fertile lines has been observed.

Induced male sterility could greatly facilitate breeding and commercial seed production if an agent which induced complete male sterility could be found. A number of chemicals (e.g. maleic hydrazide, dimethylarsinic acid, α-naphthalene-acetic acid, sodium 2,3-dichloroisobutyrate) have been used experimentally as gametocides on different plants; most showed only a small degree of success. Similar investigations have been done on the effect of animal sex hormones on the gamete fertility of plants. Some seem promising for the inducement of sterility in plants. R. K. Fendal's et al. (1) results with oestrone, a female sex hormone, for the artificial induction of male sterility in wheat were encouraging. Thus it was decided to make a preliminary study to evaluate the possible use of oestrone as a gametocide in sugarbeets.

The material used was the animal steroid hormone, oestrone, obtained in crystalline form. It is only slightly soluble in water (0.003 mg/100 ml at 25° C) and vegetable oil but is soluble in ethanol, acetone, and chloroform. Even though all these solvents except water were likely to be toxic to the plant to some degree it was decided to use these five solvents at two growth stages and their combination (premeiotic and immediate post meiotic) and with two application methods. Hence there were 30 (5 X 3 X 2) treatments and a check; there was one photothermally induced F_1 plant per treatment. The concentration of oestrone was the same in each solvent, 1 mg/37 ml of solvent. The two methods of application were: 1) 2 ml of each solution were transferred by pipet to a small vial. The main vein of one of the leaves on the plant to be treated was cut as shown in the diagram and the cut tip was placed in the vial. A hairclip held the vial in place.



2) 10 ml of each solution, under 5 lbs of pressure, was sprayed onto the plants. An atomizing sprayer was used. The three different times of application were: 1) premeiotic, 2) immediate post meiotic, and 3) treatment at both stages. Pollen viability counts were then made as each plant flowered. Counts were made from random fields on a slide stained with 0.5% tetrazolium bromide. Pollen counts of check plants were also taken.

For the vial method it was somewhat difficult to determine the amount of solution actually taken up by the plant compared to the amount evaporated, although the solution was usually gone within six hours. Uptake of the alcohol, acetone, and chloroform solutions was indicated by discoloration of the vein; this was due to their phytotoxic effect. Alcohol was extremely phytotoxic and was taken up very rapidly as the discoloration covered the whole petiole and even extended into the seed stalk on those plants receiving two treatments. No other visible effects were observed and no plants were killed by the uptake treatments. There were no visible effects due to the water treatment. For the solutions applied by spraying, chloroform was the most detrimental, being fatal to one plant. Vegetable oil covered the leaf surface very tightly and retarded growth, but the plants recovered from this satisfactorily.

Table 1. Viability counts for various treatment methods using oestrone.

Solvent	Application	% viable pollen: vials on leaves	% viable pollen: spray
Water	Premeiotic	69	90
Alcohol	"	70	87
Acetone	"	81	81
Chloroform	"	93	plant killed
Vegetable oil (spray only)	"		88
Water	Pre- & Post meiotic	52	91
Alcohol	" " "	86	84
Acetone	" " "	89	74
Chloroform	" " "	68	90
Vegetable oil (spray only)	" " "		90
Water	Post meiotic	85	88
Alcohol	" "	no reading	75
Acetone	" "	no reading	92
Chloroform	" "	88	86
Vegetable oil (spray only)	" "		87
Check		77	83
Check		95	93

A study of the pollen viability counts obtained for the various treatments, Table 1, indicated that while oestrone as applied in this study may have caused a slight inducement of male sterility, it was certainly not very effective. The majority of treatments had pollen counts of greater than 80% viability which was within the range of the checks. It was difficult to accurately compare viability counts for the various treatments since it was impossible to select flowers from each plant that had been open the same length of time or that were at their peak of viability. The lower pollen counts could be due to these factors. However the lowest counts are those from the vial method using a water solution. This could have been due to the fact that oestrone was best translocated in the water solution which was the only nondetrimental one. The same results were not seen with spraying, possibly due to greater loss of solution through evaporation. Thus, of the treatments studied, the water solution using the vial method seems to show some promise for future investigations. Further experiments are planned.

Acknowledgment

We would like to acknowledge the technical assistance of Mr. Talat Bilgen, Plant Breeder, Turkish Sugar Co., while he was working with us at Fort Collins, Colorado.

Summary

Studies were conducted in an attempt to induce male sterility in sugarbeet by the use of the female animal hormone, oestrone. Five solvents were used to make oestrone solutions. Water proved to be the best since all of the others had some phytotoxic effect on the plants. Two types of treatments were made; solutions taken up through the midvein of a leaf, and solutions sprayed directly on the plants. The first method was the most successful due to the lower evaporation losses. Three different groups of treatments were made with respect to time; premeiotic, post meiotic, and both (two applications). There were no significant differences in results between the groups. Pollen viability counts were made on each plant in the experiment. Although in several cases the viability was less than 75%, almost all treatments had a count of greater than 80%. These preliminary results are not too encouraging, but studies were not sufficiently thorough to draw any definite conclusions. Of all the treatments, oestrone in water solution, taken in through the midvein, with both pre- and post meiotic applications showed some promise of being effective for inducing male sterility in sugarbeets.

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SUGARBEET RESEARCH

1968 Report

Section E

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CONTENTS

EVALUATION OF SUGARBEET HYBRIDS AND BASIC BREEDING MATERIAL WITH LEAF SPOT AND/OR BLACK ROOT RESISTANCE

Prepared by G. J. Hogaboam

The cooperative evaluation program of the past several years with the Farmers and Manufacturers Beet Sugar Association and Northern Ohio Sugar Company, was extended in 1968 to include The American Crystal Sugar Company, Holly Sugar Company, and Cornell University. Some of the tests met with disasters of one type or another and are not reported here.

Section One: Agronomic Evaluation

Four 6x6 latin square tests were harvested. Two of these tests were in the same field. The second test in the field was to test techniques in mechanizing the harvest of experimental plots.

There was a slight increase in the coefficient of variation in machine harvest over hand harvest. Circumstances were such that the machine harvest was almost a week later than hand harvest. The differences in relative performances of the varieties between tests may be related to the type of harvest more than change due to harvest date.

The two tests in the same field on the Schroeder farm were combined prior to combining the results of the 2 Michigan and "1" Ohio tests. In combining the results of these area tests, only the data from the five common hybrids were used.

The hybrid (100363x2161)msxSP6322-0 gave the best yield of roots in tons/acre. The same female parent with 02 clone as pollen parent was consistently higher in % sucrose than when SP6322-0 was pollen parent. SL(129x133)msxSP6322-0 gave a good consistent performance in both quantity and quality. The hybrid SP6442msxSP6322-0 gave an exceptional yield response at the Smith farm at Alma, Michigan, the only place where it occurred.

Section Two: Area Evaluation

Details of the test conducted by the F & M are given in the "Notes". Various diallel tables were formed and analyzed for evidence of general combining ability of both male and female parents without success. Adjusted sugar per acre data were calculated by multiplying adjusted tons/A by adjusted pounds sugar/ton. With sugar per acre as the criteria, there were no hybrids which appeared significantly better than the present commercial hybrid SL(129x133)msxSP6322-0, also being designated as US H20.

NOTES ON AGRONOMIC VARIETY EVALUATION TESTS CONDUCTED
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RUSSELL BROS. FARM, BELMORE, OHIO.

A 56 variety area evaluation test was planted in a 7x8 rectangular lattice design with 4 replications. This test was planted for machine harvest so the plots were single row and 77½ feet long. (Two other tests of these varieties with 8 replications each were planted in Michigan for hand harvest, but had to be abandoned prior to harvest.) The test was planted 4-3 and 4-7-68 and harvested 9-26 and 9-27-68 for about 174-day growing season. The preceeding crops were: for replications 1 & 2, 1967 tomatoes and 1966 sugarbeets and for replications 3 & 4, 1967 corn and 1966 tomatoes. Plow down fertilizer was 40# N, 60# Phosphate and 120# K_2O. In the row fertilizer was 175# 6-24-12 with 10½# Mg. Sulfate. The beets were sidedressed with 70# actual N.

These beets were thinned May 14 - about an 80% stand was determined at that time. Rhizoctonia crown rot developed during the summer, such that at harvest time each plot had to be measured and cut out prior to harvest. Only competitive beets were taken for sugar samples and these were removed prior to mechanically harvesting the remainder of the plots. All plot weights and numbers per plot were adjusted to 75 feet of row before analysis.

JAMES SCHROEDER FARM, OTTAWA, OHIO.

Two 6x6 latin square experiments containing the same 6 varieties were planted adjacent to one another. One test was designed for machine harvest. In this test every other row was the commercial variety as a buffer. Each plot was one row 120 feet long. The other test was 4-row plots 30 feet long designed in the conventional manner for hand harvest. Both tests were planted 4-9-68. The previous crops were alfalfa, alfalfa, and corn for 1965 thru 1967. The broadcast fertilizer for the beets was 470#/A of this ratio: 800# 5-20-20 plus 100# urea. In addition to this 150# of 6-24-12+2% Mn was applied at planting and 50# of N was sidedressed. The seedbed was moist at planting time. The stands prior to harvest were excellent in both tests, except for a few gaps in the last replication of the hand harvest test. Leaf spot readings were made on Aug. 23, when the average rating was 2.25 and on Sept. 17, when the average rating had increased to 3.56. The 120 foot plots made leaf spot readings difficult. The hand harvest test was harvested Sept. 25 for a 169-day growing season, while the machine harvest test was harvested Oct. 1, for a 175-day growing season.

Coefficient of variation values were smaller for hand harvest than for machine harvest, although the differences were small. There was a drop in stand (beets per 100' row harvested) when the machine was used for harvesting. The tons/acre was lower with machine harvest, even though it had a 6-day longer growing season. This is probably caused by

loss of small beets and pieces of beets broken by the machine. It is disturbing to note that significant differences in one test are non-significant and the order is reversed in the other. The data from these tests were combined for purposes of comparison at other locations.

HOWARD HAYWARD FARM, BAY CITY, MICHIGAN.

A 6x6 latin square hand harvest experiment planted 4-11-68 and harvested 10-15-68 for a 187-day growing season. Previous crops 1967 melons (heavily fertilized), 1966 beans, 1965 beans. Fertilizer for the beet crop was 600# of 8-32-16. There was an excellent stand, the beets grew well, no diseases were evident, and the data are considered reliable.

DALE SMITH FARM, ALMA, MICHIGAN.

A 6x6 latin square, hand harvest experiment planted 4-27-68 and harvested 10-24-68 for a 180-day growing season. Previous crops 1967 beans, 1966 wheat seeded to mammouth clover. Fertilizer for the beet crop was 400# 5-10-30 plowed down, 400# 8-32-16 in the row, and 80# N sidedressed. There was an excellent stand, the beets grew well, no diseases were noted, and the data are considered reliable.

Combined Performance Hand and machine harvest Schroeder Farm Ottawa, Ohio 1968	Percent of General Mean					Actual	
	Recov. Sugar/A 10# bags	Roots per Acre Tons	Sugar per Ton Lbs.	Sucrose %	Clear Juice Purity %	Beets per 100' row	Leaf Spot Rating
SL(129x133)ms x SP6322-0	106.5	103.6	102.9	101.7	100.6	104.2	
(100363x2161)ms x SP6322-0	105.9	104.0	101.7	100.8	100.5	95.5	
(100363x2161)ms x 02 clone	105.3	100.7	104.8	104.5	100.1	98.8	
SP6423-01ms x SP6322-0	99.5	101.6	98.1	98.4	99.9	95.9	
SP6121-01ms x SP6322-0	92.0	96.0	96.1	97.4	99.4	92.5	
SP6322-0	90.8	94.1	96.5	97.1	99.6	91.8	
General Mean	543.4	21.75	249.7	14.64	92.75		
SE Mean	11.1	4.87	3.43	0.064	0.297		
Significant Difference (19:1)	NS	5.1	3.9	2.7	NS		
Coefficient of Variation (%)	7.1	6.2	4.7	3.2	1.1		

Combined Performance 3 locations Bay City, Michigan Alma, Michigan Ottawa, Ohio 1968	Percent of General Mean					Actual	
	Recov. Sugar/A 10# bags	Roots per Acre Tons	Sugar per Ton Lbs.	Sucrose %	Clear Juice Purity %	Beets per 100' row	Leaf Spot Rating
SL(129x133)ms x SP6322-0	103.0	102.0	101.0	100.8	100.2		
(100363x2161)ms x SP6322-0	104.5	105.0	99.4	99.1	100.0		
(100363x2161)ms x 02 clone	101.4	99.8	101.7	101.3	99.9		
SP6423-01ms x SP6322-0	98.3	99.0	99.4	99.5	99.8		
SP6322-0	92.9	94.2	98.6	99.2	100.7		
Significant Difference (19:1)	4.4	3.5	NS	NS	NS		

Schroeder Farm Ottawa, Ohio 1968, Hand harvest	Percent of General Mean					Actual	
	Recov. Sugar/A 10# bags	Roots per Acre Tons	Sugar per Ton Lbs.	Sucrose %	Clear Juice Purity %	Beets per 100' row	Leaf Spot Rating 9-17
SL(129x133)ms x SP6322-0	102.4	100.3	102.1	101.7	100.2	105.7	4.0
(100363x2161)ms x SP6322-0	108.2	105.7	102.3	101.3	100.5	100.8	3.6
(100363x2161)ms x 02 clone	101.3	98.5	103.0	102.8	100.0	98.2	4.3
SP6423-01ms x SP6322-0	102.1	103.3	98.9	99.0	99.9	102.0	4.3
SP6121-01ms x SP6322-0	91.7	97.0	94.4	96.4	99.1	97.0	2.8
SP6322-0	94.2	95.2	99.3	98.9	100.2	98.2	2.3
General Mean (actual)	537.6	22.3	240.9	14.26	92.38		3.56
SE Mean	14.8	0.525	4.44	0.165	0.462		0.172
Significant Difference (19:1)	8.1	6.9	5.4	3.4	NS		0.5
Coefficient of Variation (%)	6.7	5.8	4.5	2.8	1.2		11.8

Schroeder Farm Ottawa, Ohio 1968, Machine harvest	Percent of General Mean					Actual	
	Recov. Sugar/A 10# bags	Roots per Acre Tons	Sugar per Ton Lbs.	Sucrose %	Clear Juice Purity %	Beets per 100' row	Leaf Spot Rating
SL(129x133)ms x SP6322-0	110.5	106.9	103.6	101.8	101.0	102.6	
(100363x2161)ms x SP6322-0	103.7	102.3	101.1	100.4	100.4	90.3	
(100363x2161)ms x 02 clone	109.2	102.9	106.4	106.2	100.1	99.3	
SP6423-01ms x SP6322-0	97.0	99.9	97.3	97.9	99.8	89.7	
SP6121-01ms x SP6322-0	92.2	95.0	97.7	98.3	99.8	88.0	
SP6322-0	87.5	92.9	93.9	95.4	99.0	85.3	
General Mean (actual)	549.3	21.2	258.5	15.02	93.13		
SE Mean	16.5	0.546	4.84	0.199	0.359		
Significant Difference (19:1)	8.9	7.6	5.5	3.9	1.1		
Coefficient of Variation	7.4	6.3	4.6	3.2	0.94		

Hayward Farm
Bay City, Michigan
1968

	Percent of General Mean					Actual	
	Recov. Sugar/A 10# bags	Roots per Acre Tons	Sugar per Ton Lbs.	Sucrose %	Clear Juice Purity %	Beets per 100' row	Leaf Spot Rating
SL(129x133)ms x SP6322-0	104.0	103.0	100.9	101.0	99.9	115.8	
(100363x2161)ms x SP6322-0	105.5	107.0	98.5	98.9	99.7	116.5	
(100363x2161)ms x 02 clone	99.1	99.0	100.4	100.3	100.0	116.3	
SP6423-01ms x SP6322-0	100.1	100.2	99.8	100.0	99.9	115.7	
SP6121-01ms x SP6322-0	96.6	97.5	99.1	99.3	99.9	108.5	
SP6322-0	94.8	93.6	101.3	100.5	100.4	108.0	
General Mean (actual)	919.0	31.2	294.6	16.54	94.69	113.5	
SE Mean	17.3	0.342	3.29	0.041	0.205	1.33	
Significant Difference (19:1)	5.6	3.3	NS	NS	NS	3.9	
Coefficient of Variation (%)	4.6	2.7	2.7	0.60	0.53	2.9	

Smith Farm
Alma, Michigan
1968

	Percent of General Mean					Actual	
	Recov. Sugar/A 10# bags	Roots per Acre Tons	Sugar per Ton Lbs.	Sucrose %	Clear Juice Purity %	Beets per 100' row	Leaf Spot Rating
SL(129x133)ms x SP6322-0	98.9	98.6	100.2	99.7	100.1	98.8	
(100363x2161)ms x SP6322-0	102.2	103.1	99.1	99.2	100.0	103.7	
(100363x2161)ms x 02 clone	100.1	99.0	101.0	101.4	99.9	100.0	
SP6423-01ms x SP6322-0	95.8	94.6	101.2	101.4	99.9	110.3	
SP6442ms x SP6322-0	109.8	110.3	99.4	99.7	99.9	108.0	
SP6322-0	93.2	94.3	99.0	98.6	100.3	114.5	
General Mean (actual)	930.8	34.2	272.7	15.15	95.29	105.9	
SE Mean	21.8	0.645	4.29	0.192	0.33	2.59	
Significant Difference (19:1)	6.9	5.6	NS	NS	NS	7.6	
Coefficient of Variation (%)	5.7	4.6	3.9	3.1	0.85	6.0	

1968 Area Evaluation: Russell Bros. Farm			Performance as % of General Mean					Actual
			Adjusted for Lattice			Random Block		
FEMALE		MALE	Recov. Sugar/A	Roots per Acre	Sugar per Ton	Sucrose	Clear Juice Purity	Beets per 100'
CMS	"O" type	Multigerm	10# bags	Tons	Lbs.	%	%	row
SP6423-01		02 clone	106.6	104.9	101.6	101.6	99.8	84
"		SP6322-0	87.5	83.5	104.7	103.7	100.6	94
"		SP6629-0	89.2	93.9	94.9	95.2	100.3	94
"		SP6631-0	92.0	92.9	98.8	97.8	100.7	85
"		SP64658-3	95.7	99.3	96.4	96.4	100.2	85
SP663465-01		02 clone	90.3	92.8	97.4	97.8	99.8	90
"		SP6322-0	91.0	93.9	96.8	99.0	98.7	92
SP663465-02		SP6322-0	91.9	94.8	96.9	96.9	100.0	85
"		SP64658-3	81.2	85.1	95.2	95.3	100.2	85
SP6621-01		02 clone	90.1	89.0	101.0	99.8	100.9	88
"		SP6322-0	87.0	93.6	93.1	92.8-	100.4	92
"		SP6528-0	106.9	112.6	94.8	96.8	99.1	88
"		SP6629-0	77.0	84.9	90.9-	93.8-	98.6	88
"		SP64658-3	83.7	91.0	92.0-	92.1-	99.9	82
SL133		02 clone	114.9	108.6	106.0	103.1	101.4	93
"		SP6322-0	96.9	94.7	102.2	104.5	98.7	81
"		SP6528-0	105.2	107.0	98.2	98.0	100.4	94
"		SP6629-0	115.3	113.4	101.7	101.5	100.1	91
EL35C2		02 clone	111.3	110.3	101.0	103.8	98.8	98
"		SP6322-0	101.9	105.6	96.7	95.9	100.5	95
"		SP6528-0	98.9	102.0	97.2	97.2	99.8	86
SP581181s1		02 clone	105.1	97.2	108.2+	107.0+	100.4	94
"		SP6322-0	102.4	98.2	104.1	103.4	99.9	87
"		SP6528-0	98.2	95.9	102.5	103.5	99.6	83
"		SP6629-0	96.9	92.5	105.0	102.2	101.4	89
SP592102s1		02 clone	89.1	90.7	98.4	98.7	99.8	88
"		SP6322-0	101.5	98.0	103.6	103.7	99.8	90
"		SP6629-0	85.9	89.8	95.9	95.5	99.9	89
SP602009s1		02 clone	89.4	83.8	106.6	103.3	101.5	94
"		SP6322-0	107.9	103.1	104.6	103.1	100.5	84
SP65503-1		SP6322-0	94.2	92.7	101.7	101.9	100.1	87
FC505		"	106.0	101.7	104.1	102.3	101.0	86
SP65519-1		"	91.4	92.0	99.6	98.1	100.7	88
SP65550-1		"	117.3	114.6	102.3	101.4	100.3	96
SP65529-1		"	106.3	102.1	104.0	101.5	100.9	98
SP65599-2		"	81.6	87.2	93.8	92.9-	100.5	91
SP6423-01	SP6443	"	104.9	101.5	103.4	102.9	100.0	98
"	SP65406	"	93.8	97.7	96.1	96.7	99.9	95
SP65406-01	SP6121	"	103.2	106.6	96.7	96.6	100.3	93
"	SP6442	02 clone	106.2	107.5	98.7	100.0	99.4	100
"	"	SP6322-0	119.5	123.4+	96.9	97.9	99.3	96
"	SP643465-0	02 clone	98.5	94.6	104.2	103.8	99.9	85
"	"	SP6322-0	102.7	105.3	97.5	99.3	98.9	89
FC505	EL31	02 clone	107.4	101.4	105.9	105.8	99.5	94
"	"	SP6322-0	92.8	98.4	94.3	96.3	99.0	76
SP6423-01	"	02 clone	117.9	119.8+	98.5	102.0	98.3-	103
"	"	SP6322-0	102.1	102.4	99.8	100.2	99.7	82
"	EL35	02 clone	104.3	100.7	103.7	100.6	101.4	97
"	"	SP6322-0	109.8	103.0	106.4	104.7	100.4	92
SL129	SL133	02 clone	111.2	108.6	102.5	101.6	100.6	96
"	"	SP6322-0	119.8	112.3	106.6	104.8	100.8	94
"	"	SP6528-0	121.7	118.8+	102.3	103.9	99.7	92
EL32C2	EL31	02 clone	102.1	102.1	100.2	103.0	99.1	93
EL31C1	SP6121-0	02 clone	105.5	104.9	100.6	100.7	100.1	95
SP6121-01	EL35	SP6322-0	84.8	86.4	98.0	99.3	99.6	83
EL32C2	SP6121-0	SP6322-0	107.6	111.9	96.1	98.2	98.9	95
General Mean			637.71	22.87	278.84	15.838	94.235	-
Significant Difference (19:1)			-	16.7	7.2	6.1	1.7	-
Coefficient of Variation (%)			-	12.0	5.1	4.4	1.2	-

Cooperator: Northern Ohio Sugar Company by Phil Brimhall, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Alvin Heilman Farm, Old Fort, Ohio Year: 1968

(Results given as 8 plot averages in % of SP5822-0)[d]

Strain	Recoverable Sugar Yield[c]	Root Yield	Sugar Content	Thin Juice App. Purity	Leaf Spot[a]	Beets per 100 ft.[b]
SP6621-01 x SP6322-0	113.73	108.57+	100.11	101.91+	2.3	97
SP66406-01 x SP6322-0	110.04	114.32+	96.87	99.57	3.4	120
6722 x 070	89.66+	91.40	96.09	100.68	4.0	108
SP65503-1 x SP6322-0	115.51+	109.32	103.45	100.81+	2.6	114
SP65506-1 x SP6322-0	108.58	101.04	103.16+	101.49+	2.9	115
SP65515-1 x SP6322-0	110.49	102.92	105.88+	100.71	2.9	113
SP65519-1 x SP6322-0	114.16+	111.09	101.45	100.36+	3.0	106
SP65547-1 x SP6322-0	116.04+	110.95	100.89	101.28+	2.4	105
SP65550-1 x SP6322-0	111.59	108.19	100.38	101.11	3.4	100
SP65555-1 x SP6322-0	110.45	103.87	103.72	100.95	2.3	99
SP65599-2 x SP6322-0	112.68+	108.21	101.44	100.89	2.8	98
SP653365-1 x SP6322-0	114.62+	112.47+	98.77	101.13	3.8	120
(SP65406-01 x 6442) x SP6322-0	108.10	119.22+	91.72-	99.03+	4.0	108
(SP6423-01 x 65406-0) x SP6322-0	105.43	106.27+	95.41-	101.78+	3.8	105
(SP65406-01 x 643465-0) x SP6322-0	110.13	117.93+	94.52-	99.20	3.6	104
(SP65406-01 x 6121-0) x SP6322-0	101.37	110.23+	93.53-	99.19	2.9	96
(SP65406-01 x 65209-0) x SP6322-0	110.70	117.23+	95.85	99.20	3.1	104
(SP65502-01 x 6121-0) x SP6322-0	107.12	103.18	101.79	101.00	3.1	112
SP6423-01 x SP6631-0	91.69	93.22	96.35	100.90+	5.3	99
SP6121-01 x SP64658-3	98.56	98.44	97.20	101.27+	3.6	92
SP6423-01 x SP64658-3	91.89	86.04-	102.77+	101.79+	3.6	87
SP65502-01 x SP64658-3	113.62	102.16	108.90+	100.93	1.8	116
SP663465-02 x SP64658-3	96.43	95.16	99.73	100.37	3.1	98
EL35 x SP6322-0	105.25	111.17	95.20-	99.79	4.4	106
SP6423-01 x SP6322-0	100.64	103.99	95.34-	100.74	5.0	89
SP663465-01 x SP6322-0	94.88	103.65	93.52-	98.79	3.8	91
(SP64502-01 x 643465) x SP6322-0	108.03	106.92	100.89	99.82	2.4	100

Strain	Recoverable Sugar Yield[c]	Root Yield	Sugar Content	Thin Juice App. Purity	Leaf Spot[a]	Beets per 100 ft.[b]
(SP64502-01 x SP6442) x SP6322-0	107.63	106.84	101.26	99.82	3.3	103
(FC505 x EL31) x SP6322-0	108.24	110.61	97.71	100.22	3.6	114
(SP6423-01 x EL31) x SP6322-0	101.17	106.40	95.76	99.75	4.6	99
(SP6423-01 x EL35) x SP6322-0	106.07	105.34	99.04	100.55	4.1	104
(SP6121-01 x EL35) x SP6322-0	105.07	105.57	98.03 -	100.38	4.1	116
(EL32C2 x SP6121-0) x SP6322-0	86.83	94.74	92.97 -	99.43	4.3	104
EL35 x 02 clone	101.87	106.02	95.23 -	100.51	5.1	114
SP6423-01 x 02 clone	91.39	96.23	96.44	99.20	4.9	92
SP663465 x 02 clone	91.52	95.32	96.70	99.51	4.5	114
SP6621-01 x 02 clone	103.87	106.66	96.19 +	100.68	3.3	108
SP64502-01 x 02 clone	110.85	101.76	106.93 +	100.37	2.4	104
(SP64406-01 x 6442) x 02 clone	104.39	112.34	94.16 -	99.15	4.5	115
(SP64502-01 x 643465-0) x 02 clone	101.51	99.89	102.71 -	99.19	2.6	103
(SP65406-01 x 643465-0) x 02 clone	103.16	112.28	93.85 -	98.85	3.5	115
(SP64502-01 x 6442) x 02 clone	102.75	98.55	102.86	100.40	3.8	116
(FC505 x EL31) x 02 clone	98.94	103.01	96.11	99.66	4.1	112
(SP6423-01 x EL31) x 02 clone	104.58	106.43 +	96.55 -	100.81 -	5.3	119
(EL32C2 x EL31) x 02 clone	102.03	113.80 +	92.84 -	98.39 -	4.5	101
(EL31C1 x SP6121-0) x 02 clone	100.23	104.11	95.53	99.79	3.1	115
(SP6423-01 x EL35) x 02 clone	102.81	100.91	100.76 -	100.18	4.6	98
EL35 x SP6528-0	99.30	101.30	94.60 -	100.69	4.4	110
SP6621-01 x SP6528-0	103.09	100.83	100.11 +	100.48 +	2.8	105
SP64502-01 x SP6528-0	112.41	97.50	110.30 +	101.58 +	1.5	108
SLC133 x SP6528-0	101.57	101.86	98.09	100.25	4.1	96
SP6423-01 x SP6629-0	106.70	101.01	101.74	101.22	3.4	107
SP6621-01 x SP6629-0	108.62	105.93	99.35	100.99	2.1	93
CV (%)	13.89	12.48	4.42	1.26	-	-
Sm/Gen.Mean (%)	0.40	2.99	0.33	0.59	-	-
LSD 5% pt. (% of SP5822-0)	14.56	13.33	4.51	1.27	-	-

(a 0 = No leaf spot, 10 = complete necrosis due to leaf spot
(b Harvest stand
(c Calculated by electronic computer from formula used since 1954
(d Means for SP5822-0 are:

Recoverable sugar	5,727 lbs. per A
Roots	19.17 tons per A
Sugar	16.87 %
Purity	94.67 %

\+ Significantly above SP5822-0 at 5% pt.
\- Significantly below SP5822-0 at 5% pt.

Variance Table

Source of Variation	d.f.	Mean Squares			
		Recoverable Sugar (lbs.)(a	Roots (lbs.)(a	Sucrose (%)	Purity (%)
Replications	7	8.0981	499.88	4.1186	5.7284
Varieties	63	1.8785	111.78**	1.0950**	2.3923**
Random Block Error	397	1.4039	63.37	0.3889	1.0736
Blocks (Elim. Var.)	56	1.4144	62.08	0.7779	1.0634
Component (A)	42	1.0191	43.47	0.8385	1.0360
Component (B)	14	2.6001	117.89	0.5963	1.1454
Intra-block Error	341	1.4019	63.58	0.3252	1.0755
Total	467				

(a Pounds per plot
** Significant difference among varieties at 1% level

Analysis of variance was made for a total of 64 varieties including 53 U.S.D.A. varieties, 8 G.W. varieties and 3 check varieties.

Cooperator: Northern Ohio Sugar Company by Phil Brimhall, H. L. Bush, R. K. Oldemeyer and D. L. Sunderland

Location: Earl Longanbach Farm, Fremont, Ohio Year: 1968

(Results given as 8 plot averages in % of SP5822-0)[d]

Strain	Recoverable Sugar Yield[c]	Root Yield	Sugar Content	Thin Juice App. Purity	Leaf Spot[a]	Beets per 100 ft.[b]
SP6621-01 x SP6322-0	94.86	95.07	98.99	100.46	1.3	83
SP66406-01 x SP6322-0	107.09	107.46	99.89	99.90	1.0	84
6722 x 070	115.18	114.52	100.25	100.19	1.5	83
SP65503-1 x SP6322-0	106.47	106.56	99.17	100.50	1.0	86
SP65506-1 x SP6322-0	114.64	114.03	99.66	100.35	0.9	80
SP65515-1 x SP6322-0	104.18	101.32	101.91	100.14	1.0	95
SP65519-1 x SP6322-0	115.52	116.57	99.87	99.86	1.1	77
SP65547-1 x SP6322-0	105.14	105.31	98.69	100.48	1.5	89
SP65550-1 x SP6322-0	104.23	99.00	103.02	100.88	1.4	80
SP65555-1 x SP6322-0	120.49+	116.91	102.50	99.98	1.1	78
SP65599-2 x SP6322-0	102.27	100.76	100.31	100.37	1.0	90
SP653365-1 x SP6322-0	120.84+	125.53+	97.23	99.44	1.6	89
(SP65406-01 x 6442) x SP6322-0	111.42	113.06	98.73	99.86	1.3	81
(SP6423-01 x 65406-0) x SP6322-0	127.22+	128.87+	97.93	100.00	0.9	86
(SP65406-01 x 643465-0) x SP6322-0	105.66	110.61	96.53	99.40	1.3	77
(SP65406-01 x 6121-0) x SP6322-0	112.76	115.84	97.61	99.92	1.4	82
(SP65406-01 x 65209-0) x SP6322-0	107.01	112.17	97.83	98.89-	1.3	70
(SP65502-01 x 6121-0) x SP6322-0	102.51	100.78	100.77	100.21	1.0	78
SP6423-01 x SP6631-0	114.50	122.70+	95.21-	98.82-	2.6	94
SP6121-01 x SP64658-3	103.00	105.03	98.03	100.30	1.0	76
SP6423-01 x SP64658-3	115.14	116.35	98.82	99.68	1.4	73
SP65502-01 x SP64658-3	91.05	84.97	104.57+	101.05	0.8	78
SP663465-02 x SP64658-3	97.60	100.18	97.37	100.02	1.8	82
EL35 x SP6322-0	122.39+	121.87+	100.59	99.86	1.5	80
SP6423-01 x SP6322-0	108.72	108.96	98.15	100.15	2.1	72
SP663465-01 x SP6322-0	110.06	116.06	95.44-	99.25	1.4	77
(SP64502-01 x 643465) x SP6322-0	104.97	105.15	101.10	99.07	1.0	71

Strain	Recoverable Sugar Yield[c]	Root Yield	Sugar Content	Thin Juice App. Purity	Leaf Spot[a]	Beets per 100 ft.[b]
(SP64502-01 x SP6442) x SP6322-0	103.56	103.66	100.11	99.60	1.4	76
(FC505 x EL31) x SP6322-0	109.02	106.92	99.51	100.46	1.5	93
(SP6423-01 x EL31) x SP6322-0	117.31	119.70	99.15	99.26	2.0	89
(SP6423-01 x EL35) x SP6322-0	118.49	115.20	102.33	100.25	1.5	80
(SP6121-01 x EL35) x SP6322-0	118.90	119.37	99.93	99.97	1.4	82
(EL32C2 x SP6121-0) x SP6322-0	115.63	121.68+	96.93	98.90-	0.8	79
EL35 x 02 clone	112.66	113.31	100.81	99.04	2.0	83
SP6423-01 x 02 clone	109.93	106.53	102.36	100.14	2.5	82
SP663465 x 02 clone	116.92	117.32	100.17	99.31	1.5	84
SP6621-01 x 02 clone	110.43	112.21	99.62	99.60	1.3	69
SP64502-01 x 02 clone	112.23	106.39	103.95+	100.62	1.1	80
(SP64406-01 x 6442) x 02 clone	107.14	104.73	101.98	100.00	1.9	84
(SP64502-01 x 643465-0) x 02 clone	100.09	97.09	102.05	100.34	0.9	81
(SP65406-01 x 643465-0) x 02 clone	105.59	110.76	97.49	98.87-	1.8	86
(SP64502-01 x 6442) x 02 clone	110.22	105.89	103.89+	100.15	2.3	89
(FC505 x EL31) x 02 clone	108.50	104.93	103.50	99.92	1.8	88
(SP6423-01 x EL31) x 02 clone	105.56	103.99	100.75	99.99	1.9	72
(EL32C2 x EL31) x 02 clone	109.51	114.01	98.71	98.82-	2.4	81
(EL31C1 x SP6121-0) x 02 clone	104.86	107.43	98.50	99.70	2.1	84
(SP6423-01 x EL35) x 02 clone	105.99	102.70	102.46	99.93	1.9	76
EL35 x SP6528-0	125.49+	122.44+	100.76	100.34	1.4	88
SP6621-01 x SP6528-0	110.59	110.23	99.30	100.56+	1.3	73
SP64502-01 x SP6528-0	99.36	91.49	104.82+	101.39+	1.1	74
SLC133 x SP6528-0	117.54	119.48	98.86	99.84	1.4	80
SP6423-01 x SP6629-0	118.81	116.59	99.44	100.74	1.0	80
SP6621-01 x SP6629-0	91.88	92.91	98.12	100.28	1.1	73
CV (%)	18.19	18.20	3.39	1.10	-	-
Sm/Gen.Mean (%)	0.59	2.81	0.30	0.37	-	-
LSD 5% pt. (% of SP5822-0)	19.82	19.90	3.51	1.08	-	-

(a 0 = No leaf spot, 10 = complete necrosis due to leaf spot
(b Harvest stand
(c Calculated by electronic computer from formula used since 1954
(d Means for SP5822-0 are:

Recoverable sugar	5,574 lbs. per A
Roots	23.05 tons per A
Sugar	14.61 %
Purity	91.70 %

\+ Significantly above SP5822-0 at 5% pt.
\- Significantly below SP5822-0 at 5% pt.

Variance Table

Source of Variation	d.f.	Mean Squares			
		Recoverable Sugar (lbs.)(a	Roots (lbs.)(a	Sucrose (%)	Purity (%)
Replications	7	10.7734	357.12	12.0039	30.2537
Varieties	63	1.1161**	76.61**	4.1545**	5.3484**
Random Block Error	397	0.6364	36.56	0.4916	1.3924
Blocks (Elim. Var.)	56	0.8488	52.17	1.0700	1.7331
Component (A)	42	0.9074	48.18	1.0426	1.6989
Component (B)	14	0.6731	64.16	1.1519	1.8355
Extra-block Error	341	0.5990	34.05	0.3985	1.3325
Total	467				

(a Pounds per plot
** Significant difference among varieties at 1% level

Analysis of variance was made for a total of 64 varieties including 53 U.S.D.A. varieties, 8 G.W. varieties and 3 check varieties.

Leaf Spot Notes on USDA Hybrids at Mason City, Iowa
1968

Hybrid - East Lansing	LSR Index 1 - 5	Root Rot 1 - 6
E1 35c2 x 02	2.5	2
" x SP 6322-0	1.5	2
" x SP 6528-0	3.0	2
SP 6423-01 x 02	3.5	2
" x SP 6322-0	2.5	2
" x SP 6629-0	2.0	3
SP 663465-01 x 02	1.5	2
" x SP 6322-0	2.0	2
SP 6621-01 x 02	2.0	4
" x SP 6322-0	2.0	4
" x SP 6528-0	2.5	3
" x SP 6629-0	1.5	3
SP 64502-01 x 02	1.0	2
" x SP 6528-0	1.5	2
FC 502 x SP 6629-0	3.5	2
SL 133 x 02	3.0	2
" x SP 6322-0	2.5	1
" x SP 6528-0	2.5	2
" x SP 6629-0	2.0	4
(SP 65406-00 x SP 6442) x 02	2.5	2
" " x SP 6322-0	3.0	2
(SP 64502-01 x 643465-0) x 02	1.5	2
(SP 64502-01 x 643465-0) x SP 6322-0	1.5	1
(SP 65406-01 x 643465-0) x 02	2.5	3
" x SP 6322-0	2.0	2
(SP 64502-01 x SP 6442) x 02	2.0	3
" x SP 6322-0	1.5	2
(FC 505 x E1 31) x 02	1.5	3
" x SP 6322-0	2.5	2
(SP 6423-01 x E1 31) x 02	3.0	2
" x SP 6322-0	2.5	2
(E1 32c2 x E1 31) x 02	2.5	2
(E1 31c1 x SP 61210) x 02	1.5	3
(SP 6423-01 x E1 35) x 02	2.0	2
" x SP 6322-0	2.5	2
(SP 6121-01 x E1 35) x SP 6322-0	1.5	1
(E1 32c2 x SP 6121-0) x SP 6322-0	2.5	1
(SL 129 x 133) x 02	3.5	3
" x SP 6322-0	3.0	3
" x SP 6528-0	2.0	3
Hybrid - Beltsville		
6621-01 x SP 6322-0	1.0	3
66406-01 x SP 6322-0	2.0	2
663455-02 x SP 6322-0	2.0	2
65503-1 x SP 6322-0	1.5	2
65506-1 x SP 6322-0	1.5	2

Leaf Spot Notes Continued:

Hybrid - Beltsville	LSR Index 1 - 5	Root Rot 1 - 6
65515-1 x SP 6322-0	1.5	1
65519-1 x "	1.0	2
65547-1 x "	2.0	3
65550-1 x "	1.5	2
65555-1 x "	1.5	2
65599-1 x "	1.5	2
653365-1 x "	2.0	2
(65406-01 x 6442) x SP 6322-0	1.5	2
(65406-01 x 643465) x "	2.0	2
(65406-01 x 6121-0) x "	2.5	3
(65406-01 x 65209-0) x SP 6322-0	2.0	3
(65502-01 x 6121-0) x "	1.0	3
6423-01 x 6631-0	2.5	3
6121-01 x 64658-3	1.5	2
6423-01 x 64658-3	1.5	2
65502-01 x "	1.0	2
663465-02 x "	2.5	2
(6423-01 x 65406-01) SP 6322-0	—	3

Notes: Leaf Spot Index: 1 = resistant, 5 = susceptible.

Plots: Two row plots, 25 feet long, 2 replications
Dates: August 15 and August 26

Data: Average of 2 row plots at 2 dates

Root Rot Index: 1 = excellent, 2 = good, 3 = fair, 4 = poor, 5 = very poor, 6 = no beets.

Plots: Two row plots, 25 feet long.

Index: Early October

Results of cooperative agronomic evaluation test of USDA varieties, East Grand Forks, Minnesota , 1968 (8 plot averages).
By American Crystal Sugar Company

Description	Seed number	Entry no.	Acre Yield: Gross sucrose Lbs.	% $\bar{x}$	Roots Tons	% $\bar{x}$	Sucrose %	% $\bar{x}$	Impurity Index ppm/%	% $\bar{x}$	Raffinose % on D.S.	% $\bar{x}$
SP 6423-01 x SP 6322-0	505	1	2675	95.2	12.18	98.1	10.98	97.1	1341	110.5	.358	102.9
SP 663465-01 x 02	507	2	2551	90.8	11.08	89.2	11.51	101.8	1154	95.1	.317	91.1
SP 6621-01 x SP 6322-0	510	3	2742	97.6	12.09	97.3	11.34	100.3	1146	94.4	.451	129.6
(SP 65406-01 x SP 6442) x SP 6322-0	521	4	3060	108.9	13.47	108.5	11.36	100.4	1169	96.3	.329	94.6
SP 65519-1 x SP 6322-0	547	5	3019	107.4	13.48	108.5	11.20	99.0	1368	104.4	.287	82.5
SP 643465-02 x SP 6322-0	543	6	2819	100.4	12.71	102.3	11.09	98.1	1189	97.9	.316	90.8
SP 65555-1 x SP 6322-0	550	7	2583	91.9	11.42	91.9	11.31	100.0	1283	105.7	.363	104.3
(SL 129 x 133) x SP 6322-0	Am #2 Hybrid "B"	8	3028	107.8	12.93	104.1	11.71	103.5	1166	96.0	.365	104.9
General Mean			2809		12.42		11.31		1214		.348	
L.S.D. (.05)			424		--		.31		--		.075	
F Value			--		NS		4.48**		NS		3.51**	
C. V. %			15.07		14.83		2.71		14.56		21.49	

Variance Table a/

Source of Variation	D/F	Mean Squares (variance): Roots (lbs.)	Sucrose %	Imp. Index	Raffinose
Replications	7	693.64	4.0971	771,791	.007849
Varieties	7	219.08	.4243	42,216	.019660
Error	49	118.03	.0948	31,223	.005601
Total	63	193.21	.5762	108,063	.007413

a/ For gross sucrose, SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\left(\frac{\text{SE lbs. beets}}{\text{mean lbs. beets}}\right)^2 + \left(\frac{\text{SE \% sucrose}}{\text{mean \% sucrose}}\right)^2}$$

Results of cooperative agronomic evaluation test of USDA varieties, Bird Island, Minnesota, 1968 (8 plot averages).

By American Crystal Sugar Company

Description	Seed number	Entry no.	Acre Yield: Gross sucrose lbs.	% $\bar{x}$	Roots Tons	% $\bar{x}$	Sucrose %	% $\bar{x}$	Impurity Index ppm/%	% $\bar{x}$	Raffinose % on D.S.	% $\bar{x}$
SP 6423-01 x SP 6322-0	505	1	5394	98.1	19.14	100.8	14.09	97.2	686	109.9	.314	118.1
SP 663465-01 x 02	507	2	5243	95.4	18.41	97.0	14.24	98.3	654	104.8	.259	97.4
SP 6621-01 x SP 6322-0	510	3	5326	96.9	18.19	95.8	14.64	101.0	601	96.3	.294	110.5
(SP 65406-01 x SP 6442) x SP 6322-0	521	4	5439	98.9	18.78	98.9	14.48	99.9	628	100.7	.257	96.6
SP 65519-1 x SP 6322-0	547	5	5558	101.1	19.14	100.8	14.52	100.2	632	101.3	.232	87.2
SP 663465-02 x SP 6322-0	543	6	5462	99.4	19.03	100.2	14.35	99.0	645	103.4	.289	108.7
SP 65555-1 x SP 6322-0	550	7	5983	108.8	20.16	106.2	14.84	102.4	568	91.0	.286	107.5
(SL 129 x 133) x SP 6322-0	Am #2 Hybrid "B"	8	5613	102.1	19.00	100.1	14.77	101.9	579	92.8	.194	72.9
General Mean			5500		18.98		14.49		624		.266	
L.S.D. (.05)			564		—		--		69		.056	
F Value			--		NS		1.23	NS	2.70*		3.91**	
C. V. %			10.21		9.14		4.56		10.96		20.89	

Variation Table a/

Source of Variation	D/F	Mean Squares (variance): Roots (lbs.)	Sucrose %	Imp. Index	Raffinose
Replications	7	181.30	1.6000	40,138	.002,587
Varieties	7	96.92	.5386	12,619	.012,063
Error	49	104.54	.4361	4,682	.003,087
Total	63	112.22	.5768	9,504	.004,029

a/ For gross sucrose, SE lbs. sucrose = mean lbs. sucrose x

$$\sqrt{\frac{(\text{SE lbs. beets})^2}{(\text{mean lbs beets})} + \frac{(\text{SE \% sucrose})^2}{(\text{mean \% sucrose})}}$$

DEVELOPMENT OF BREEDING MATERIAL RESISTANT TO LEAF SPOT AND BLACK ROOT

G. E. Coe

Research under Foundation Project 26 at the Plant Industry Station, Beltsville, Maryland, is directed mainly toward varietal improvement in resistance to Cercospora leaf spot and Aphanomyces black root. This program contributes to the synthesis of many varieties and hybrids evaluated in field tests in Michigan and Ohio.

The results reported here cover progress of basic breeding material, leaf spot resistance of some new O-type and male-sterile lines, results of a combining ability test, and developments in greenhouse methods of testing for disease resistance.

Trends of Basic Breeding Stocks

Since 1964 there has been little improvement in resistance to Cercospora leaf spot in the basic multigerm or monogerm breeding stocks. However, the level of resistance is substantially better than that of the commercial hybrid presently used in the Michigan area. When hybrids with combining ability equal to or better than that of the present commercial hybrid are developed from these stocks, substantial leaf spot protection will be realized. The trend of a slight yearly increase in Aphanomyces black root resistance in the basic breeding stocks appears to be continuing, and it is estimated that they are now about 10% more resistant to this disease than the present commercial hybrid.

Basic breeding stocks have shown no increase in root yield since 1964. The basic multigerm breeding lines appear to have increased slightly in percent sucrose since 1962 when tested at Beltsville, Maryland. However, this improvement is less than 1% per annum and has not responded readily to selection efforts. Selection restrictions require that improvement in sucrose percentage not be made at the expense of root yield. Since 1961, the multigerm breeding stocks have definitely been lower in nonsucrose constituents than the standard check variety, US 401. Improvement in this characteristic is so slow, however, that it is difficult to assesss. It will be difficult to determine when selections no longer result in improvement. The monogerm breeding stocks were notoriously high in nonsucrose constituents and are just now equal to US 401 in this characteristic.

Leaf Spot Tolerance of New Monogerm O-Type Lines

Many new, apparent O-types were found in 1968. To test their tolerance to Cercospora leaf spot, they were started in the greenhouse and transplanted to the nursery. Leaf spot readings are presented in table 1.

Table 1.--Leaf spot readings of new O-type and male sterile-companion lines in 1968 Nursery, Beltsville, Md.

Seed No.	Leaf spot rating*	Seed No.	Leaf spot rating*
SP 6322-0 MM PF (Resistant check variety)	2.3		
SP 6764. mm PF	3.0	SP 67561. mm PF	2.5
SP 6764-01 mm MS	3.0	SP 67561-1 mm MS	2.0
SP 67508. mm PF	1.0	SP 67569. mm PF	2.0
SP 67508-1 mm MS	1.0	SP 67569-1 mm MS	1.0
SP 67509. mm PF	2.0	SP 67588. mm PF	1.5
SP 67509-1 mm MS	1.0	SP 67588-1 mm MS	2.0
SP 67513. mm PF	2.0	SP 67507-1 mm MS	1.0
SP 67513-1 mm MS	1.0	SP 67510-1 mm MS	1.0
SP 67514. mm PF	2.0	SP 67511-1 mm MS	1.0
SP 67514-1 mm MS	2.0	SP 67512-1 mm MS	2.0
SP 67517. mm PF	3.5	SP 67516-1 mm MS	2.0
SP 67517-1 mm MS	3.5		
		SP 67527-1 mm MS	1.0
SP 67523. mm PF	3.0	SP 67532-1 mm MS	1.0
SP 67523-1 mm MS	2.0	SP 67535-1 mm MS	1.0
SP 67524. mm PF	5.0	SP 67544-1 mm MS	1.0
SP 67524-1 mm MS	2.5	SP 67550-2 mm MS	1.0
SP 67534. mm PF	1.0		
SP 67534-1 mm MS	2.0	SP 67553-1 mm MS	2.0
		SP 67568-2 mm MS	1.0
SP 67542. mm PF	2.0	SP 67587-1 mm MS	1.0
SP 67542-2 mm MS	3.0	SP 67589-1 mm MS	3.0
SP 67543. mm PF	1.0		
SP 67543-1 mm MS	1.0		
SP 67557. mm PF	1.5		
SP 67557-1 mm MS	2.0		

* 0 = No leaf spot; 10 = All leaves dead.

It will be noted that the leaf spot resistance of 34 of the lines tested appeared to be as good as or better than that of the resistant multigerm check variety, SP 6322-0, whereas 10 lines appeared to have less resistance. The degree of leaf spot resistance in most new monogerm O-types produced at Beltsville is quite satisfactory; but one with superior combining ability must be found in order to produce a hybrid that is better than the present commercial variety.

Combining Ability Tests

In 1967, crosses were made between individual pollen-fertile plants and a male-sterile beet from each of four different male-sterile lines. Seed harvested separately from each male-sterile plant resulted in four hybrid progeny from each pollinator. These hybrid progeny were tested in the 1968 leaf spot nursery at Beltsville. Leaf spot and production results for 20 of these hybrids are presented in tables 2 thru 6.

Table 2.--Average leaf spot readings of 20 hybrids in combining ability tests. 1968 Nursery, Plant Industry Station, Beltsville, Md.

Male parent	Female parent				Male average
	6121-01	6540-01	663465-02	6423-01	
65B15-4	3.00	3.00	3.33	5.00	3.58
6322-0 (No.1)	3.67	3.67	3.67	4.33	3.84
6322-0 (No.2)	3.33	3.33	4.67	4.67	4.00
6322-0 (No.3)	3.00	3.33	4.00	5.33	3.92
65B15-27	4.00	2.67	4.00	4.00	3.67
Female average	3.40	3.20	3.93	4.67	

Table 3.--Gross sugar production of 20 hybrids in combining ability tests (lbs/acre). 1968 Nursery, Plant Industry Station, Beltsville,Md.

Male parent	Female parent				Male average
	6121-01	6540-01	663465-02	6423-01	
65B15-4	1826	4001	2898	2901	2907
6322-0 (No.1)	1898	3335	2355	2760	2587
6322-0 (No.2)	1980	3443	2667	2258	2587
6322-0 (No.3)	2791	2977	2910	2471	2787
65B15-27	2576	2996	3232	2842	2912
Female average	2214	3350	2812	2646	

Table 4.--Root yield of 20 hybrids in combining ability test (tons/acre). 1968 Nursery, Plant Industry Station, Beltsville, Md.

Male parent	Female parent				Male average
	6121-01	6540-01	663465-02	6423-01	
65B15-4	8.98	17.91	13.67	12.87	13.36
6322-0 (No.1)	9.37	14.72	10.58	12.29	11.74
6322-0 (No.2)	9.00	14.59	11.80	9.71	11.27
6322-0 (No.3)	12.00	12.23	13.69	10.87	12.20
65B15-27	12.92	12.94	14.39	12.54	13.20
Female average	10.45	14.48	12.83	11.65	

Table 5.--Percentage sucrose of 20 hybrids in combining ability test. 1968 Nursery, Plant Industry Station, Beltsville, Md.

Male parent	Female parent				Male average
	6121-01	6540-01	663465-02	6423-01	
65B15-4	10.17	11.17	10.60	11.27	10.80
6322-0 (No.1)	10.13	11.33	11.13	11.23	10.96
6322-0 (No.2)	11.00	11.80	11.30	11.63	11.43
6322-0 (No.3)	11.63	12.17	10.63	11.37	11.45
65B15-27	9.97	11.50	11.23	11.73	11.11
Female average	10.58	11.59	10.98	11.45	

Table 6.--Percentage soluble nonsucrose solids in 20 hybrids in combining ability test. 1968 Nursery, Plant Industry Station, Beltsville, Md.

Male parent	Female parent				Male average
	6121-01	6540-01	663465-02	6423-01	
65B15-4	3.05	2.73	2.86	2.59	2.81
6322-0 (No.1)	2.81	3.31	3.37	2.92	3.10
6322-0 (No.2)	2.87	2.96	2.92	2.81	2.89
6322-0 (No.3)	3.06	3.31	2.95	2.74	3.02
65B15-27	2.72	3.00	2.84	2.64	2.80
Female average	2.90	3.06	2.99	2.74	

In table 2 it can be seen that hybrids from SP 6121-01 mm MS and from SP 6540-01 mm MS were in general better in resistance to Cercospora than hybrids from the other two female lines. Hybrids from SP 6423-01 mm MS were definitely less resistant. The poor resistance of SP 663465-02 mm MS X SP 6322-0 (No. 2) poses the problem of whether a specific gene combination or a variation between individual plants of the MS line was the cause. This is an extremely important question which must be answered before the most effective means of determining combining ability can be found. Experiments are being set up to find the amount of variation caused by differences between plants within male-sterile lines.

The comments on variation between hybrids in leaf spot resistance are also applicable to yield results. In table 3 it can be observed that, in general, hybrids derived from the male-sterile line SP 6540-01 mm MS gave the highest gross sugar yield. However, the hybrid SP 6540-01 mm MS X SP 65B15-27 produced much less than it should have. It is necessary to determine whether this is due to specific combining ability or to variation of plants within the male-sterile line.

Developments in Greenhouse Methods of Testing for Disease Resistance

The effect of high humidity in controlled environment chambers on increasing the severity of Aphanomyces black root infection was reported in Sugarbeet Research, 1967 Report. A simple device was constructed to increase the humidity around plants being tested in the greenhouse. A frame with hardware cloth was placed 2 inches above the plants. A layer of cheesecloth was placed over the hardware cloth and draped down to the greenhouse bench to maintain humidity. This arrangement uniformly increased the severity of Aphanomyces infection. A preliminary test indicated that plastic film will maintain humidity even better than cheesecloth.

The effectiveness of the method in increasing Aphanomyces attack led to its application to greenhouse testing for Cercospora resistance. The cheesecloth was replaced by a polyethylene film cover. In the first experiment, a resistant variety, SP 6822-0 (P), and a susceptible variety were tested. Differences between them were both observable and measurable. Further experiments are being conducted to determine whether it is possible to observe and measure smaller differences in resistance among varieties having more disease tolerance.

SUGARBEET DISEASE INVESTIGATIONS AT EAST LANSING, MICHIGAN IN 1968

C. L. Schneider

I. Black root disease

1. Greenhouse screening tests of resistance to Aphanomyces cochlioides. - Seed lots developed at the East Lansing station by G. J. Hogaboam and R. C. Zielke were grown in the greenhouse in soil infested with zoospores of a culture of the beet water mold, A. cochlioides. Disease severity ratings based on a numerical system from 0 (no symptoms) to 5 (dead) were assigned approximately 30 days after inoculation. In a series of 22 tests, 211 seed lots were screened for resistance. The average disease severity index of variety US 401, included in each test as a standard for comparison, = 3.0. To summarize; 69.2 percent of the entries were rated as more resistant than US 401, 28.4 percent were about equal in resistance, and only 2.4 percent were rated as more susceptible.

2. Studies on inoculum of A. cochlioides.- Studies were continued on production and employment of A. cochlioides oospore inoculum. In comparison of efficacy of various nutrient media at different concentrations for oospore production, oatmeal proved to be the most satisfactory thus far. On oatmeal agar (80 g./L) the fungus produced over 260 oospores per mm^2, which exceeded more than twenty-fold production on agar containing other nutrients formerly employed for oospore inoculum production, including maize meal and maize kernal decoction. Oospore inoculum was produced by growing the fungus in flasks containing 1 part oatmeal decoction and 2 parts vermiculite for approximately one month, after which contents of the flasks were removed and thoroughly dried. The material is infectious when added to soil in which sugarbeet seedlings are grown, presumably because of the activity of the oospores which are borne on the vermiculite particles. When quantities as low as 1 ml were added with seed in 4" pots of sterile soil, typical black root symptoms developed on seedlings 10-30 days later. Differences in seedling resistance to A. cochlioides, similar to those noted when zoospore inoculum is employed, were also noted with oospore inoculum. Dried cultures of the fungus containing oospores that ranged in age from 12 days to 19 months were infectious to sugarbeet seedlings. Studies are now continuing on methods of mass production of Aphanomyces oospore inoculum and on the feasibility of employing it in greenhouse and field inoculations.

II. Rhizoctonia crown and root rot

1. Study of pathogenic capability of Rhizoctonia solani isolates. - Among 9 Michigan isolates of the fungus from seedlings, older plant roots and blighted leaves, there were pronounced differences in pathogenicity on sugarbeets. Only isolates from older plants were able to incite crown and root rot. All isolates were pathogenic on seedlings.

2. Test for resistance to R. solani. - A field test was conducted to determine degree of resistance to a local isolate of the pathogen of 5 sugarbeet lines developed for Rhizoctonia resistance at Fort Collins, Colorado by J. O. Gaskill. Also included in the test for comparison and for possible selection of resistant plants were 8 breeders' lines developed at the East Lansing station with no background of selection for Rhizoctonia resistance. Plants were inoculated, after thinning, with dried and ground sorghum grain inoculum according to previously described methods[1], and typical symptoms of crown and root rot appeared shortly thereafter. At harvest, numerical disease ratings ranging from 0 (no symptoms) to 5 (dead) were determined for the entries. Disease ratings of the 5 lines designated as Rhizoctonia-resistant ranged from 1.8 to 3.1, whereas disease ratings of the other lines ranged from 4.1 to 4.9. This striking difference in degree of Rhizoctonia resistance between the two groups was readily discernible in the field plots because of differences in numbers of plants surviving and in severity of symptoms on the survivors. Among surviving plants in the East Lansing lines, 26 were selected as possible sources of Rhizoctonia resistance in the breeding program.

III. Fungicide tests[2]

In field tests conducted in cooperation with H. S. Potter, Dept. of Plant Pathology, Michigan State University, fungicides and special methods of application were tested for efficacy in controlling three major sugarbeet diseases of the humid area: black root, Rhizoctonia crown and root rot, and Cercospora leaf spot.

In a test on black root disease control, 4 seed treatments and 4 soil treatments were evaluated under a moderately-severe, epiphytotic in a field naturally infested with the beet water mold, Aphanomyces cochlioides. By mid-summer, stands in untreated plots were reduced approximately 50% by the disease. Fungicides that gave stands significantly higher than in control plots were: Dexon[3], Daconil 2787[3] and Daconil-Terrazole[3], which were applied as soil treatments at planting.

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[1] Pierson, Victor G., and John O. Gaskill. 1962. Artificial exposure of sugar beets to Rhizoctonia solani. Jour. Amer. Soc. Sugar Beet Tech. 11:574-590.

[2] This is a report on the current status of research on pest control practices. It does not contain recommendations for the use of pesticides nor does it imply that the uses discussed have been registered. All uses of pesticides must be registered by appropriate State and Federal agencies before they can be recommended.

[3] Trademark names. Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the USDA and does not imply its approval to the exclusion of other products that may also be suitable.

In a test for Rhizoctonia crown and root rot control, plots were infested with dried sorghum grain cultures of a crown-rotting isolate of R. solani. Loss of plants in the ensuing epiphytotic in treated as well as untreated control plots was excessive and none of 11 seed and soil treatments tested effectively controlled the disease.

A test of fungicides to control leaf spot was conducted in a field artificially infested with Cercospora beticola inoculum. Twenty-one fungicide spray treatments were applied six times at 14-day intervals beginning in early July. The most outstanding control was obtained with duPont Fungicide 1991[3], Merck TBZ[3], and Du-Ter[3].

An evaluation of low volume aerial spraying for control of Cercospora beticola was made in a commercial field in Monroe County, Michigan. Selected copper compounds applied at 14-day intervals and a standard dithiocarbamate fungicide applied at 14- and 21-day intervals gave satisfactory disease control. The results indicate that further tests to determine the feasibility of a 21-day spray interval are warranted.

More detailed accounts of the aforementioned fungicide tests are included in "Fungicide-Nematicide Test Results of 1968" (in press), published by the American Phytopathological Society.

PHYSIOLOGICAL INVESTIGATIONS - 1968 [1/]

F. W. Snyder

Germination Studies:

Both field- and greenhouse-grown "seed" of a few varieties was harvested by individual plants. Usually some fruits were harvested when the moisture content ranged from 225 to 280%, again when the moisture content was intermediate (110 to 190%), and when the fruits were straw-colored and ranged in moisture content from 25 to 60%. For most plants grown in the greenhouse, the harvest extended in excess of a month. Portions of the fruits were subjected to 4 treatments: (a) Drying at laboratory temperature, (b) drying rapidly in forced air at 120 F, (c) refrigerated at 40 F for 4 to 5 days then dried at laboratory temperature, and (d) refrigerated for 4 to 5 days then dried in forced air at 120 F. After the fruits were dry, each sample was hand processed to remove the corky material. The fruits were not soaked or treated with a fungicide. Samples of fruits harvested at the different moisture contents and subjected to the different treatments were placed on the same blotters to minimize environmental differences during germination. Accumulated percentage germination was recorded daily to determine the effect of the maturity and treatments. All data were corrected for fruits containing no seed or a poorly developed seed that was judged to be nonviable after the 7-day period for germination.

The complexity of the experiment is magnified by genetic diversity. As a result, few clearcut consistent trends were apparent. On the other hand, the range of differences was sufficiently great to establish significant responses to both maturity and treatments. The following statements appear to be valid on the basis of results to date: (a) Maturity did not affect the total percentage germination, even when moisture contents at harvest were as high as 280%. (b) Plants within a given progeny group exhibited a marked range of response to a given treatment; some germinated more rapidly and others more slowly as a result of a given treatment. (Varieties also differed in response.) (c) When seeds harvested over this wide range of maturity were germinated, seeds of six plants germinated more rapidly as the seeds were more nearly mature, seeds of 10 plants germinated less rapidly, seeds of five plants had no clearcut trend, and seeds of two plants germinated distinctly slower for intermediate maturity than for either less mature or more mature. (d) Refrigerating the fruits for 4 or 5 days altered speed of germination by more than 10 percentage points in about half the samples, as compared with samples not subjected to refrigeration. Sixteen samples germinated more rapidly and 7 more slowly. (e) Drying the fruits in forced air at 120 F (Treatment 2) tended to slow the rate of germination and was more detrimental for the fruits with the higher moisture content. Total germination was not affected, however.

[1/] Research conducted in cooperation with Michigan Agricultural Experiment Station.

In contrast to earlier data for seed grown in Arizona and Oregon, in which both speed and percentage germination increased as seed maturity progressed, these data do not reveal any effect of maturity on percentage germination and no consistent trend in speed of germination over the wide range of maturity. Both sets of data are valid, without question. Some of the factors which could account for the different responses are (a) different varieties, (b) fruits from Arizona and Oregon were not processed, but those in the recent experiment were processed (Recently, some data for processed and non-processed fruits from the Oregon seed indicated no great effect of processing on altering the pattern of germination performance as compared with the non-processed control treatment.), (c) the range in maturity of the Arizona and Oregon seed was considerably less than in the recent experiment. Additional study is under way on the complex and varied germination responses observed in sugarbeet.

Translocation Studies:

Effect of Foliarly Applied Growth Regulators on Translocation of Photosynthate in Sugarbeet.

Sugarbeets were grown at least 60 days on complete mineral nutrient (+N) solution. Then, half of the plants were given minus-nitrogen (-N) solution. After nitrogen deficiency developed, all but 3 uniform, nearly mature leaves were removed from a +N and a -N plant. One leaf was the control, the second was treated with N-6 benzyl adenine (BA), and the third with either gibberellic acid A_3 (GA), indole-3-acetic acid (IAA), or kinetin (Ki). The solutions were 1.5×10^{-4} M. Ten to 15 hr later, in AM, the solutions were swabbed (either 4 or 9 times) on the blades. About 6 hr later, the plant was placed in a plexiglass chamber and $C^{14}O_2$ was released. One hr later, the blades and petioles were cut off. The C^{14}-compounds were extracted by boiling in 80% ethanol and in water. Total activity of the combined extracts was determined by liquid scintillation. For a given plant, the percentage of activity in the petiole of the treated leaf was compared with that of the control leaf. All translocation data are expressed on the basis of the control equal to 100%.

BA significantly retarded translocation out of the blade (92%). Nitrogen status of the plants did not alter the response to BA. Following data based on 4 or 5 replications. Ki retarded translocation (76% for +N plants and 96% for -N). GA stimulated translocation in +N plants (116%), but retarded translocation in -N plants (90%). IAA did not affect translocation consistently.

Physiological Studies on Sugarbeets[1/]

R. M. Cressman[2/]

Histochemical Localization of Sugar

Because of the solubility of sugars, definite histological localization of sucrose in the beet tissue has been difficult to accomplish. Gomori (1) cites a method used by Okamoto et al. (2) which presents a possible technique. Basically, the method involves the precipitation of sucrose as the barium saccharate and the replacement of the barium with silver. Development of the silver produces a black deposit which indicates where the sucrose was originally present. The precipitation reaction is not exclusive for sucrose, of course, but since sucrose usually constitutes about 99% of the sugar in the beet, reasonable assumptions can be made.

The procedure, as applied in the present case, is as follows. Sections of beet tissue about 150 microns thick are placed in methanol saturated with barium chloride. The barium saccharate is visible as an opague precipitate. At this stage the gross appearance of sugar in the cells can be seen. I have then processed the sections through the silver treatment in a manner similar to the standard procedure for histochemical localization of calcium. The method as applied to fresh sections has produced varied degrees of success, but shows enough promise to warrant expectations of usefulness.

Efforts to fix pieces of beet tissue in barium chloride-saturated methanol by freeze-substitution procedures with subsequent embedding in paraffin, sectioning, and processing have so far met with little success.

Mobility of Sugar in Beet Tissue

Sucrose is accumulated in the cells of the sugarbeet root in large quantities. Studies on the mobility of sugar in the root may help in understanding the mechanism of sugar accumulation.

1/ This research was conducted in cooperation with the Department of Plant Pathology and the Agricultural Experiment Station, University of Minnesota, St. Paul, Minnesota and the Department of Plant Pathology and the Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota.

2/ Plant Physiologist, United States Department of Agriculture, Agricultural Research Service, Fargo, North Dakota.

Procedure

Small discs are cut from the sugarbeet root and placed in various solutions. The amount of sugar which diffuses into the solution is measured by removing an aliquot and analyzing for sugar. One-tenth ml. of liquified phenol is added to the aliquot, then 3 ml. of concentrated sulfuric acid is added. The absorption of resultant color development is measured at 488 mu and compared with a standard.

Measurements taken during the first 30 minutes showed a rapid sugar loss during the first 5 minutes. The amount of sugar loss in this time is roughly equivalent to the amount of sugar calculated to be present in the injured cells. Therefore, the discs of beet tissue are pre-soaked in distilled water for exactly 5 minutes before the start of diffusion experiments.

Most of the experiments to date have been conducted with potassium phosphate solutions. Trials with other salts, sodium chloride, potassium chloride, borate, and acetate gave similar results.

Diffusion with respect to pH was studied by using various proportions of KH_2PO_4 and K_2HPO_4 with constant phosphate concentration. Phosphate salts have been used in most of the diffusion experiments.

Results

After 7 hours usually only 5 to 10% of the sugar in the beet slices diffuses into the external solution. The rate of diffusion is fairly rapid at first but gradually decreases to a relatively low rate. The rate of diffusion was, on the average, minimal at a pH of 6 to 7. The rate gradually increased to a pH of 9, the highest used. There was also a tendency for an increase in rate at the lower pH's (lowest used was 4.5) after 6 hours of diffusion, but not at earlier times.

The rate of diffusion of sugar into distilled water is usually much greater than into a salt solution. The rate of diffusion into dilute salt solutions from 10^{-1}M to 10^{-4}M increases with decreasing salt concentration. The rate of diffusion from 0.1M to 0.5M is roughly similar.

Much variation occurred in these experiments, some of which may be due to the individual beets. However, the greater diffusion rates in weak salt solutions and distilled water was rather consistent. After 7 hours the amount of sugar which diffused into distilled water averaged about twice as much as that which diffused into 0.1M phosphate solution.

Discussion

The variation encountered has necessitated a large number of repetitions. Some variation may be due to the individual characteristics of the beet or its previous history or perhaps to the portion of the beet used. When a standard set of conditions can be established, diffusion of sugar will be studied in relation to various substances affecting metabolism.

The present data show a considerable resistance to diffusion of sugar from living beet cells. The mechanism by which the sugar is held within the cells may be related to mechanism of sugar accumulation. A study of the effect of metabolically active substances may help to elucidate the factors involved.

Literature Cited

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Root and Storage Rots[1/]

A. S. Heagle[2/] and R. M. Cressman[3/]

Fungi Isolated from Storage Rot and the Effect of Temperature on Their Pathogenicity

Fungi were isolated from stored beets and their virulence tested at several temperatures.

Stored mother beets were obtained from the American Crystal Sugar Company at East Grand Forks, Minnesota. Fungi were isolated from lesions observed on these beets and healthy beets were then inoculated with these fungi. Fungi recognized include Phoma, Rhizoctonia, Fusarium, and Alternaria. Rhizoctonia was most commonly isolated (43% of the isolates).

Table 1 summarizes the relative amounts of decay for the various fungi. The greatest amount of decay occurred at 26-30°C, but substantial decay also occurred in several cases at the lower temperatures. Difference in amounts of decay occurred even between the 12° and 14° C treatments despite the relatively small interval. No decay occurred in check beets in which cores were made and sealed without including fungus inoculum. Generally, a given isolate produced the same amount of decay in all 5 replicates at a given temperature.

The results of this study indicate that a number of fungi are present in stored beets in the Red River Valley and that unnoticed but possibly economically important losses may occur due to storage decay. For example, beet pile temperature records at East Grand Forks for 1967 were usually well above 14°C for over a month. Thus, the temperature was favorable for the growth of decay fungi.

1/ This research was conducted in cooperation with the Department of Plant Pathology and the Agricultural Experiment Station, University of Minnesota, St. Paul, Minnesota.

2/ Formerly Research Assistant, Department of Plant Pathology, University of Minnesota, St. Paul, Minnesota.

3/ Plant Physiologist, United States Department of Agriculture, Agricultural Research Service, St. Paul, Minnesota; Presently at Fargo, North Dakota.

Table 1. Relative severity of the decay in sugarbeet roots.

Fungus	Isolate No.	Incubation Temperature (°C) 26-30	14	12
Rhizoctonia	4	23	6	3
"	7	22	0	0
"	10	27	6	4
"	15	36	12	2
"	18	21	10	7
"	48	12	6	9
Fusarium	9	43	6	5
"	33	2	0	0
Phoma	3	22	5	3
Alternaria	43	1	0	0
Unknown	13	0	0	0
"	17	26	0	0
"	36	29	5	4
"	49	26	2	1

Damping Off of Sugarbeet Seedlings

Several soils were tested for the presence of damping-off organisms and the effectiveness of several control procedures examined.

Seeds of American #2 Hybrid B sugarbeet seed were treated with various fungicides. The seed was dried and then planted in soils from 4 sources as listed in Table 2. Twenty seeds were placed in each pot and 5 pots were included in a treatment. The number of plants emerged after 7 days and the number of apparently healthy plants after 14 and 21 days were recorded. Fungi were isolated 5, 10, and 19 days after planting from plants displaying disease symptoms.

In the Blue Earth soil, emergence was generally good except for thiobendazol-treated and untreated seeds. Effective control by seed-treatment chemicals was most difficult to accomplish in the Blue Earth soil. None provided effective

Table 2. Soil used in damping off study

Location	Cooperator	Remarks
Blue Earth, Minn.	Don Farrus	1965-67 - Corn 1966-68 - Beets
Moorhead, Minn.	Olaf Midgarten	Field has had Rhizoctonia
East Grand Forks, Minn.	Russell Steen	Robert Kinney Farm; Damping off and wireworms affected beets in 1967
Greenhouse soil		Steamed

Table 3. Fungi commonly isolated from diseased seedlings at 5, 10, and 19 days after planting

Soil	Days after planting		
	5	10	19
Blue Earth	Most Pythium spp. Some Rhizoctonia sp.	Pythium spp. Aphanomyces cochliodes	Aphanomyces cochliodes
Moorhead	Pythium spp. Rhizoctonia sp.	Pythium spp. Rhizoctonia sp.	Aphanomyces cochliodes
East Grand	Mostly Pythium spp. Some Rhizoctonia sp.	Mostly Pythium spp. Some Rhizoctonia sp.	(small amt.) Rhizoctonia Pythium spp.
Sterile	None	None	None

control of Aphanomyces, which was present in seedlings as soon as 10 days after planting and had severely affected all treatments by 22 days after planting. The best treatments in the Blue Earth soil contained Chemagro 4497 or Dexon.

In the Moorhead soil, chemicals also failed to protect seedlings adequately against Aphanomyces. Thiobendazol again appeared to increase the tendency towards damping off. The treatments which were most effective in the Moorhead soil all contained Dexon but not all Dexon treatments were as effective.

The East Grand Forks soil did not appear to be heavily infected with damping off organisms but all treatments except three were better than the untreated check. Again, thiobendazol treatments showed an increase in damping off.

Fungi which were associated with damping off are listed in Table 3. Pre-emergence damping off was usually associated with Pythium spp. but Rhizoctonia sp. was also important in the Moorhead soil. Aphanomyces cochloides was the most important fungus associated with post-emergence damping off in the Blue Earth and Moorhead soils but was absent from the East Grand Forks soil.

Dexon, used in commercial treatment of seed, was best in controlling damping off. But Chemagro 4497 approaches Dexon in effectiveness and appears to warrant further testing. Although commercially-treated seed (Dexon) was the most effective of all the treatments used in this investigation, it was not effective in preventing damping off in Blue Earth soil. Aphanomyces shows up later than Pythium and Rhizoctonia and is less susceptible to control by the fungicides used.